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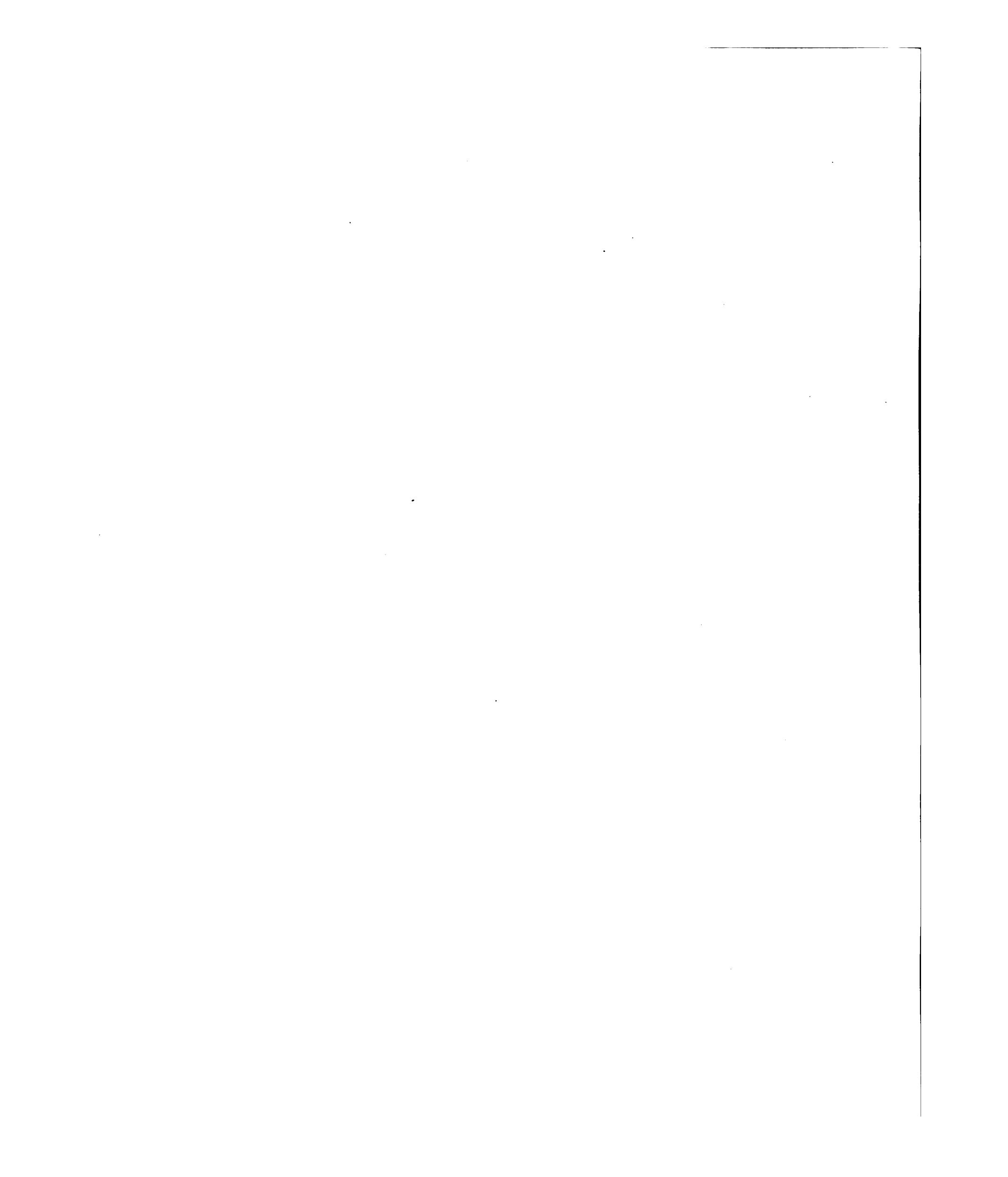
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## SKETCH

OF THE

# GREAT HISTORIC MINES

OF THE

CERRO DE PROAÑO AT FRESNILLO,

State of Zacatecas, Mexico.

<sup>1884</sup>  
Benjamin J. Gillman.

— New Haven, Conn.  
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## C O N T E N T S.

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	<small>PAGE.</small>
Prefatory Note, .....	v
Authorities Cited, .....	vi-vii
General Statement:—The Fresnillo and Cerro de Proaño Mines,.....	ix
Changes Introduced by the Railway System, .....	x
Annual Out-put of Precious Metals in Mexico,.....	xii
Data Relating to the former History of the Mines of the Cerro de Proaño, Report by Don Pascual Arenas, 1859, .....	xiii xiv
Report of Messrs. Auld and Buchan, .....	xv
M. St. Clair Duport, .....	xv
Report by Don Joaquin M. Ramos, .....	xvi
Disastrous Public Events, .....	xvii
Detailed Statement of the Affairs and Dividends of the Proaño Mines, 1841-1849,.....	xvii
The Dividends prior to 1850, .....	xviii
The Decline in the Out-put of Bullion at Proaño after 1850, and its Causes, .....	xviii
Report of Manuel Ortega & Son,.....	xix
Joseph Burkart's Notice of the Proaño Mines in his " <i>Reisen in Mexico,</i> "	xix
General Conclusions,.....	xx
Rapport Général sur les Mines de Fresnillo, ou du Cerro de Proaño, .....	xxv-xxxix
[Translation of the foregoing General Statement, etc.]	

## APPENDIX.

	PAGE.
Geological and Mineralogical Description of the Mining Region of Fresnillo, by Don Pascual Arenas,-----	I
Key to the Spanish Names on the Map of Sr. Arenas,-----	8
Notice of the Silver Mines of Fresnillo, by Auld and Buchan,-----	II
M. Duport's Notice of Fresnillo and of the Mode of Treatment of the Ores in the <i>Hacienda Nueva</i> ,-----	30
Plan of the <i>Hacienda Nueva</i> of Fresnillo,-----	33
Report on the General Condition of the Proaño Mines on Jan. 6, 1865, by Joaquin M. Ramos,-----	43
Report of Manuel Ortega & Son,-----	51
Report on Height of Water in the Beleña Mine, July 27, 1867, by Augustin Pró,-----	57
General Report to the <i>Junta Menor Permanente</i> , Oct. 10, 1844,-----	59
Distribution made in Mexico of the Net Profits from Dec. 18, 1841, to June 3, 1843, -----	64
Dividends paid from Jan. 20, 1843, to Nov. 14, 1849,-----	65
Tabular Statement of Materials Consumed, Yield of Ore and Silver, and Cost of Production from 1853 to 1862 inclusive,-----	66
Extracts from Joseph Burkart's " <i>Reisen in Mexico</i> ,"-----	68
Treatment of Silver Ores by the <i>Patio</i> Process, translated from Duport's Work, -----	72

*PREFATORY NOTE.*

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*At the request of DON MANUEL DARQUI Y LEGUIA, of Zacatecas, acting for the owners, the following sketch of the past history and present condition of the FRESNILLO SILVER MINES has been prepared.*

*Every statement in this sketch is drawn from authentic documents, some of which are now first published, and the full titles of which will be found in the list of Authorities Cited. Of these the full text, when important, will be found in the Appendix, translated from the original Spanish, German or French, with the assistance of Mr. W. A. GOODYEAR, M. E., late Government Geologist for the Republic of Salvador, Central America.*

*B. SILLIMAN, M. A., M. D., N. A. S.,*

*American Inst. Mining Engineers.*

*New Haven, Conn., April, 1883.*

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*Noticia Sobre las Minas de Plata del Fresnillo en El Estado de Zacatecas, República Mejicana, etc.* (Notice of the Silver Mines of Fresnillo, etc., etc.) By ROBERT O. AULD AND JOHN BUCHAN. London, 1834. Translated from the Spanish.

*Descripción Geológica y Mineralógica del Mineral del Fresnillo.* (Geological and Mineralogical description of the Mining Region of Fresnillo.) By DON PASCUAL ARENAS, Professor of Exploitation in the Practical School of the National School of Mines, Mexico, 1849. 8vo., pp. 55, with a map. Translated and abridged from the Spanish.

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**GENERAL STATEMENT: THE FRESNILLO AND CERRO  
DE PROAÑO MINES.**

THE "FRESNILLO" is one of the great historic mining properties of Mexico, situated in the State of Zacatecas, fourteen leagues northwest of the city of Zacatecas, upon the Mexican plateau, about 7000 feet above sea level, in a salubrious region and upon the line of the Mexican Central Railway, the stakes for which have been driven in front of the famous "*Hacienda Nueva*," or reduction works of Fresnillo.

Fresnillo is not a *mine*, in the ordinary sense of that term, but rather a large group of mines forming a plexus of numerous silver-bearing veins intersecting the hill known as the *Cerro de Proaño*, which

rises only 350 feet or so above the general level of the plain. At the foot of this hill is the city of Fresnillo, a town of 8000 inhabitants, chiefly miners and metallurgists.

The area embraced within the boundaries of this property is about four and a half square miles. Within this area on the *Cerro de Proaño* are more than twenty shafts sunk upon as many veins but opening by cross cuts many more. The number of veins already more or less exploited is stated to exceed fifty. During the period of active work these veins furnished 900 tons of ores weekly to the great reduction works of the Hacienda Nueva without adequately exploring the entire property.

The hill of *Proaño* is covered over with the waste and debris of old workings commenced, it is said, soon after the Spanish occupation, revived about the middle of the eighteenth century, 1750-1759, subsequently arrested by the influx of water, until the early years of the present century; but not prosecuted with much energy or profit until after the war of revolution, when, in 1824, the State of Zacatecas opened the Fresnillo mines to work by contract on account of the State. Subsequently (1832), by the establishment of the "Central System," these mines passed into the hands of a company, which divided the profits with the Central Government, nominally on equal terms, but in reality upon a basis which gave the Government the lion's share, as will be seen by details given beyond.

By an ordinance of date 1878, March 15, the *Cerro de Proaño* mines are for a period of ten years free from every description of impost from both the State and Central Governments. The property is now held by Manuel Ortega & Son, assignees of the Mining Company of Fresnillo.

#### *CHANGES INTRODUCED BY THE RAILWAY SYSTEM.*

The rapid development of the railway system in Mexico is removing many obstacles formerly in the way of cheap mining, by putting machinery, fuel, salt, quicksilver, explosives and other materials, at greatly reduced cost, delivered by rail to the very mouth of the mines. An examination of the careful analysis appended of the Fresnillo

expense accounts, Feb. 1, 1838 to Jan. 31, 1839, by M. Duport, shows that over one-half the cost of reduction, at that time, was embraced in the two items of mercury (34 per cent.) and salt (17 per cent.) These two important items of cost are now reduced more than one-half, even before the arrival of the railway system.

Fuel, in the form of English coke, can now be laid down in ballast at Tampico, duty free, at a nominal advance upon the shipping cost in Wales, and transported to Zacatecas City by the line of rail already in process of construction, and thence by the "Mexican Central," of which system it is a part, to Fresnillo, a total distance of about 400 miles, and will run the steam pumps and reduction works at a reduced cost compared with the oak wood hitherto used as fuel and costing  $37\frac{1}{2}$  cents per Spanish quintal, or estimating the cord at 3500 pounds, say \$13 per cord.

The accompanying sketch map shows the different lines of railway hitherto projected and in various stages of progress of construction. A glance will show that Fresnillo is on the main line of the Mexican Central, connecting it with the U. S. on the north, with the city of Mexico on the south and with the port of Tampico on the Gulf of Mexico. By a branch of the same line, already in active operation, Guaymas, on the Gulf of California, is also connected with Fresnillo, and ultimately the Sinaloa line from Mazatlan and Culiacan will connect these seaports with Durango and Zacatecas.

Already in 1838 the use of steam pumps at Fresnillo had reduced the cost of unwatering the mines, as compared with the old system of *Malacates*, or horse whims, employing 2000 animals and 500 men, to one-fifth of its former cost.

Cheaper fuel will not only reduce the cost of all mechanical work about the mines and reduction works, but may very probably enable the managers to use smelters for the class of so-called rebellious ores which do not work so well in the *Patio*. Railway transportation will easily introduce lead ores and other basic fluxes, carrying a certain quantity of silver, from both the south and the north, where such ores abound, rendering the smelting of the so-called rebellious ores easy and economical. The great improvements made during the past twenty years in mechanical drilling of hard rocks, in high explosives, concen-

tration apparatus, rock breakers, pulverizers and mining machinery generally, as well as in smelting, all soon to be rendered available at Fresnillo by railway transportation, go far to revolutionize old methods and to bring a large class of ores, formerly considered too low grade to be mined and reduced, at a profit, into the rank of valuable reserves, of which the quantity in the Proaño is known to be very large.

*ANNUAL OUTPUT OF PRECIOUS METALS IN MEXICO.*

The present annual output of precious metals is officially stated, for 1880-81, at \$29,713,355, not including the considerable amounts obtained by prospectors, but only what has come to the knowledge of the officers of the Mexican Government.

The average amount coined annually, for the years 1874 to 1879 inclusive, taken from the official records of the seven mints, all upon the lines of the Mexican Central R. R., aggregates \$19,132,120.55. Of this sum the mint at Zacatecas produced in these years an average of \$4,950,706.30. Since 1880 this mint has produced nearly six millions annually, being the largest amount from any mint in the Republic.

The gross sum coined in Mexico from the year 1690 to 1865, inclusive, being 176 years, is stated by M. P. LAUR, a French engineer, in the *Annales des Mines* (loc. cit.) as follows:

Silver, -----	\$2,194,978,639
Gold, -----	103,071,903
	<hr/>
	\$2,298,050,542

This immense sum—averaging a little more than \$13,000,000 per annum for the whole time—falls far short of expressing the grand total of bullion produced by Mexico down to the date stated, which is probably an aggregate of not less than three thousand millions of dollars.

The material fact is that since the restoration of order in Mexico the total output is steadily increasing and it is not too much to believe that it will soon equal the amount produced before the downfall of the Spanish power, when it exceeded fifty millions annually.

The possibilities of the future in the production of the precious metals in Mexico are such as to well nigh dazzle the imagination. As

yet little has been done in smelting argentiferous lead ores, of which the quantity is known to be immense, and the same is true of gold and silver-bearing copper ores. M. Duport concludes his work on the production of the precious metals in Mexico (1843), with the following statement:

"The lack of capital, the lack of public tranquillity, the lack of population and culture in the northwestern part of the Republic, the lack of sufficient scientific knowledge, and still further the high price of mercury, are the causes which hinder the development of production of the precious metals in Mexico. These causes will continue to exercise their fatal influence for some years yet to come, preventing the production from reaching, and even surpassing, the figure which we have seen it reach at the beginning of this century.

"But these causes are not permanent. They are only temporary, and must in the long run be at first neutralized and afterwards dominated by more powerful forces, such as the abundance of ore, and the progress of science, which pushes farther and farther every day the limits of human knowledge and power. The time will come, a century earlier or a century later, when the production of silver will have no other limits than those which are imposed upon it by the ever increasing diminution in its value."

The opening up of Mexico by the railway system was an event not contemplated by M. Duport in 1843, or he certainly would have included so important a factor, which is destined (to use his comparison) to bring about the result he foretold "a century earlier."

*DATA RELATING TO THE FORMER HISTORY OF THE  
MINES OF THE CERRO DE PROAÑO.*

The data relating to the former history of the mines of Proaño, or Fresnillo, are abundant and authentic, covering its successive epochs of activity, both before the introduction of steam engines for unwatering the mines and subsequently to that event and to the erection of the famous Hacienda for the beneficiation of the ores. Translations of these documents are presented herewith, and it is only by their perusal, in detail, that the reader can obtain an adequate idea of the nature and extent of this immense *Stockwerk*; of the amount of work which

has been done in its exploration and of the yet greater work, of the same kind, which awaits the advent of the new order of things attending the opening of these regions to modern methods by the railway system.

*REPORT BY DON PASCUAL ARENAS, 1859.*

Sr. ARENAS, Professor of Exploitation in the Practical School (at Fresnillo) of the National Mining School of Mexico, has prepared from the labors of his pupils a clear and satisfactory notice of the Fresnillo mining region, accompanied by the only map we have showing the course and direction of the veins, with sections of the formations and of the workings. A study of this geological and mining map in connection with the data contained in the Report, and other writings presently to be mentioned, is very instructive and demonstrates the fact that a very large amount of mining ground, known to be intersected by numerous veins of silver ore, has not been explored, if at all, beyond the depth of about 40 fathoms.

This important memoir bears the date, Nov. 1859, during the prosperous administration of Don José Gonzales Echeverria, who conducted with a slight interruption the affairs of Fresnillo for twenty-seven years, until his death in 1864. We shall have occasion to refer again to this remarkable man. Prior to the organization of the prosperous *Zacatecano-Mexicana* Company in 1835, the Legislature of the State of Zacatecas, by a decree passed in the year 1830, assumed the direction of the Fresnillo mines, then abandoned and full of water, working them by convict labor assembled from all parts of the State. We have only a general statement with few details of this effort beyond the averment that good results were obtained. Thus it appears by the statement of Messrs. Auld and Buchan, for the year from Nov. 30, 1832, to Nov. 30, 1833, there was a profit of \$149.000 on a total output of a little more than one and a half millions of dollars. The struggle with water was too much for the horse whims (*Malacates*), which at that time were the only means of unwatering these mines, and the political disturbances withdrew a considerable part of the working force from exploration and extraction. This memoir is given in full on p. 1.

*REPORT OF MESSRS. AULD AND BUCHAN.*

The next most important document setting forth the history of the Fresnillo mines is that issued in London, July 4, 1834, by Messrs. Auld and Buchan, English mining engineers, long resident in Mexico and perfectly familiar with the history of Fresnillo and with the Mexican methods of mining. This document, *Notice of the Silver Mines of Fresnillo*, was translated into Spanish by order of the Honorable Congress and was reprinted by Pedro Piña, Zacatecas, 1835. Not being able to discover a copy of the English original, a translation in full from this Spanish edition is annexed, p. 11. The map referred to in the text has been lost. This is of less moment now, as we have the later map of Don Pascual Arenas, already mentioned. This document will well repay an attentive perusal as forming an important link in the history of these remarkable mines. It is especially interesting as a candid statement from two thoroughly competent and experienced English miners, long accustomed to the administration of large mining works. The facts they present are of great interest as showing the favorable contrast attending the efforts (1830–1833) on behalf of the Mexican government to rehabilitate the Fresnillo mines as compared with the wasteful expenditures and lamentable losses attending the efforts of some of the English companies, at that time, to renovate certain famous old Mexican mines, which did not respond gratefully to the money wasted on them. A reference to the notes appended to the paper of Messrs. Auld and Buchan will give all needful details on this point.

*M. ST. CLAIR DUPORT.*

This eminent French mining engineer long resident in Mexico, has given us in his valuable treatise "*On the production of the Precious Metals in Mexico, 1843*," a full account of the Fresnillo mines, a translation of portions of which is appended. At the time when Duport wrote this valuable paper, steam had replaced animal power in unwatering the Fresnillo mines and the *Hacienda Nueva* had been constructed by Sr. Anitua at a cost of over \$340,000, and was in full activity under the able direction of Don José Gonzales Echeverria. The price of quicksilver, salt, magistral and fuel was still high and the item of animal power

employed about the works was 12 per cent. of the total cost of treatment in producing a mark of silver. The careful analysis of the whole cost of this treatment and of the loss of Mercury in the *Patio* process, as developed at Fresnillo, is most instructive. Of the Mexican *Patio* something in more detail will be found beyond, also cited from M. Duport.

*REPORT BY DON JOAQUIN M. RAMOS.*

Sr. RAMOS, the Mining Superintendent of the Proaño Company at that time, and a mining engineer of eminence, now residing at Zacatecas, presented in 1865 a brief but detailed report on the state of the Proaño mines at that date and subsequent to the death of Echeverria. Sr. Ramos' report will be studied with interest as being (excepting Ortega's) the latest and most authentic testimony we have respecting the condition of the mines at that time and now, as well. But little work has been done since in any but the upper levels. It is evident to a mining engineer that Sr. Ramos was hampered by a false economy on the part of his Directors, in extending works of exploration into new and promising ground, by the want of suitable means to secure shafts and levels requiring care, to provide ventilation, and by the want of fuel and consequently of pumping power to unwater the lower levels of the mines. In spite of all these difficulties it is obvious, from a careful study of his data, that there remains an ample reserve of good ores immediately available, and with plenty of unexplored ground at moderate depths within the limits of the *Cerro de Proaño* without the necessity of sinking the deep shafts any deeper, for a long time to come, provided some of the numerous comparatively shallow shafts are sunk, with good judgment, where he indicates the existence of valuable ore bodies quite unexplored. But his advice was evidently unheeded, since in 1867 another engineer, Augustin Pró, rendered to the Company a report on the height of the water in the Beleña mine. It will be seen by an examination of this report (page 57) that the unfortunate change of administration had already seriously reduced the output of the mines and involved a large expense in unwatering them again. This unfortunate state of affairs went from bad to worse, until 1872, when the entire property again reverted to the State.

*DISASTROUS PUBLIC EVENTS, 1857-1867.*

The so-called war of reform and the confiscation of ecclesiastical properties, the French occupation of Mexico and all its deplorable consequences, fell upon this unfortunate country during 1857-67. The period of depression in the affairs of the Mines of Proaño, the exile of the excellent Echeverria, and the consequent mal-administration of the mines but fairly reflects the disasters which attended the general upturning at that time of all public and private affairs.

*DETAILED STATEMENT OF THE AFFAIRS AND DIVIDENDS OF THE PROAÑO MINES, 1841-1849.*

A detailed statement of the affairs of the Proaño mines of date, Oct. 10, 1844 (see pp. 59, 65) will be found of interest from the accuracy with which each minute item of material consumed is tabulated through this series of years. The following abstract gives the main results of the nine years' work, viz :

The mines produced in gross value,	\$18,641,194.36
The cost of mining, reduction and administration, was	17,088,718.22
Available for distribution as profits,	\$1,552,496.14
This net sum was thus distributed, viz:	
Loaned to the Supreme Government,	\$1,099,194.00
Paid debts contracted by Government,	193,518.00
Net profits, so-called, paid Government,	<u>499,665.75</u> \$1,792,377.76
Leaving an apparent deficit for 9 years, of	\$239,901.61

The sum of over one million of dollars must be added to the above gain earned by the mines and expended in permanent improvements which remain of value to this day.

These items are as follows, viz :

Cost of the <i>Hacienda Nueva</i> ,	\$340,132
Cost of two steam engines complete,	504,860
Cost of various structures, new or renovated,	68,625
Cost of two additional steam engines (in part),	100,865
Cost of the permanent improvements paid out of the mines,	\$1,014,485
Profit before named,	<u>1,552,496</u>
Profit of nine years work of the mine,	\$2,566,981

*THE DIVIDENDS PAID PRIOR TO 1850.*

From Dec. 18, 1841 to Nov. 14, 1849, inclusive, the amounts paid in dividends by the Proaño mines were \$3,046,890.61; or an average of \$385,000 per annum. This period is in part that included in the statement just presented. The figures are given in detail on pp. 64-65.

*THE DECLINE IN THE OUTPUT OF BULLION AT PROAÑO  
AFTER 1850, AND ITS CAUSES.*

The period of ten years from 1853 to 1862, inclusive, embraces a large part of that period of profound political disturbance in Mexico, already alluded to during which the mining explorations were seriously interrupted at the mines of Proaño, as well as elsewhere in Mexico. Large amounts of low grade ores which had been rejected in former years were then mined and worked at a loss, while it is asserted that so little care was exercised in the selection of ores after the exile of Echeverria that large quantities of comparatively worthless material were passed through the process of beneficiation, so that the average of good ores was reduced below the point of profit. We are not therefore surprised at the figures which we deduce from the detailed tabular statement given on page 66. During these ten years the quantity of ore extracted was 3,092,530 $\frac{3}{4}$  cargas = 463,879.6 montones, or tons, while the quantity worked was 452,264.8 montones or tons, being 11,614.8 tons less than the quantity extracted. See on p. 66 the detailed statement from which these figures are condensed.

The total cost of extraction was \$10.903 per *monton*, of which \$8.531 was for mining and \$2.372 for pumping.

The cost of beneficiation was \$11.170 per *monton*, making the total cost of mining and working the ore equal \$22.073 per *monton*. The average yield of the 452,264.8 *montones* which were beneficiated, was \$21.725 per *monton*.

It thus appears that the result of this whole ten years was an average loss of 34.8 cents per *monton*, aggregating in the neighborhood of \$160,000.

During this period, the total product of the mines was \$9,825,595.68. If this result was unexplained by the reasons already given, it

might be supposed, naturally, that it was due to the exhaustion of the richer ores worked in the former decade. But it appears from the data supplied in the carefully prepared paper of Sr. Ramos, already cited, that the ores were not drawn from the lower levels of the mines, and that in 1865 the amount of the better classes of ores fit for the *Patio* was large and increasing, in spite of the neglect which had crept into the management after the exile of Echeverria. It is even asserted at the present day, that there was a determination on the part of certain persons in authority to impair the value of the property for sinister purposes by intentionally reducing the grade of the ores supplied to the Hacienda.

*REPORT OF MANUEL ORTEGA & SON.*

This report is dated Fresnillo, March 24th, 1881, and was rendered to the shareholders of the *Mining Company of Fresnillo*, at its date, by Messrs. Ortega & Son, as assignees of the property. It contains valuable information as to the present condition of the property and of the work in actual progress, both in the mines and the Hacienda. It states that three hundred tons of ore are now weekly taken from three of the mines, for treatment in the Hacienda, the returns from which are sufficient to pay all the costs of pumping and maintenance. They certify that everything is in good order at Proaño and in the Hacienda. The pumps are driven only by day to supply water for the reduction works, thus limiting exploration to the uppermost levels of a limited number of veins. The steam engines which now drive the stamp mills and arrastras in the reduction works take the place of the numerous animals and their attendants formerly employed on the same work, greatly in the interest of economy. See pp. 51, 56.

*JOSEPH BURKART'S NOTICE OF THE PROAÑO MINES IN HIS "REISEN IN MEXICO."*

The general geological, mineralogical and metallurgical character of the rocks and ores of the *Cerro de Proaño* and of the adjacent plain are so clearly and completely set forth in the several memoirs already cited that it is hardly necessary to multiply testimony on these points.

At the same time the reader may refer with advantage to the statements of the late eminent German engineer, *Joseph Burkart*, long resident in Mexico (1825–1834) in charge of the Bolaños mine on the Veta Grande, in Zacatecas, and who in his well-known "*Reisen in Mexico*," has recorded the result of his studies, especially in Zacatecas. So much of his text as relates to Fresnillo is presented herewith, and will be read with interest as the candid testimony of a most competent and experienced observer, specially familiar from long study with the ores of Zacatecas, which now principally concern us. See pp. 68–71.

*GENERAL CONCLUSIONS ESTABLISHED BY THE UNITED  
TESTIMONY OF ALL AUTHORITIES WHOSE RESULTS  
ARE AVAILABLE AND SEVERAL NOW FOR  
THE FIRST TIME MADE PUBLIC.*

From the unanimous testimony of all the authors and authorities whose statements are here quoted, the following facts may be considered as well established:

1st. *The system of silver-bearing veins* explored at Fresnillo, as well those in the *Cerro de Proaño*, as their extensions in the adjacent plains, is found in the geological and lithological relations in which the famous mines of Zacatecas, Guanajuato, Guadalajara, San Louis Potosi, etc., etc., are all found. They are all fissure veins in so-called "Gray-wacke" and metamorphic clay-slate of (probably) Devonian age. These veins at Fresnillo are very numerous and generally not large, but by a singular peculiarity to be explained presently, they are exploited over a wider range than the width of the fissures which they fill.

2d. *The veins of Fresnillo carry three classes of ores*, distinguished as "*los Colorados*," "*los Negros*," and "*los Azulaques*."

a. *Los Colorados*, the red ores, are distinguished as carrying chiefly native silver, silver chloride, or chlorobromide (*plata verde*), mingled with reddish iron oxides and quartz veinstone, rarely with some remains of unoxydized ores. In short, the red ores mark the zone of decomposition influenced by the atmosphere and its waters, and the depth to which they penetrate varies considerably in different veins. The *Colorados*

at Fresnillo have averaged about  $3\frac{1}{2}$  ounces of silver to the hundred pounds of raw ore.

b. The *Negros*, or black ores, are essentially quartz veinstone, carrying the black sulphurets of silver, argentite and brittle silver ore chiefly, with some dark and light red silver, native silver, iron pyrites, and rarely some copper, zinc and lead sulphides, the latter more rare than the iron pyrites and zinc which in certain veins (e. g. *San Pedro*) is too common for the good of the mine, as this class of ores is poorer in silver and is essentially a smelting ore. In short the '*Negros*' are ores that have escaped the influence of decomposition which have elsewhere produced *los Colorados*. The value of *los Negros* at Fresnillo may be fairly stated at 4 oz. per 100 lbs. of ore, on the authority of Burkart and Dupont.

c. *Los Azulaques* (the bluish ores), are essentially peculiar to the silver veins of the *Cerro de Proaño*. Burkart distinctly says they are not found at Zacatecas, e. g. on the Veta Grande or Malanoche. They consist essentially of the same ores found in the adjacent veins, distributed in the body of the country rock, for a distance of from  $\frac{1}{2}$  a vara (16") to 1 vara (32") away from the vein. For this distance the country rock is found to be impregnated with iron pyrites, argentite, horn silver and native silver in very small particles. The horn silver and native silver are found in thin coatings. On the cleavage surfaces of the rock, the native silver presents a brilliant metallic lustre, and it is this, with the *plata verde*, which guides the eye of the miner in judging whether it will pay to break the rock or not. An inexperienced miner would be apt to reject rock which on crushing and washing in the horn spoon or miner's pan, gives a large residue of metallic particles, chiefly horn silver and virgin silver. The average of the *Azulaques* is put by Burkart at 3 oz. per 100 lbs. of ore. It is the occurrence of this rich impregnation of the rocks, outside the vein proper, which distinguishes the mines of the *Cerro de Proaño* as compared with any other mining regions yet discovered in Mexico, and which makes it profitable to work veins so narrow, that, but for this fortunate circumstance, could not be mined to a profit.

An interesting question for investigation, whenever the old workings of the Fresnillo are again opened, is whether it may not pay to

examine them for *Azulaques*, which, with modern means of concentration and ore-dressing, may be readily brought up to a profitable state for the *Patio*, although with the slow and costly modes of mechanical treatment exclusively in use here formerly, they fell below a renumerative tenure of silver, and were consequently left standing. If this suggestion should be sustained by experimental proof, the quantity of such ores will probably be found very large, and available at very moderate cost. Fortunately the water supply at Fresnillo, drawn from the mines themselves, is ample for any plan of wet concentration which may be adopted.

3d. *The reserves of ore at Fresnillo are ample.* Not more than one-third part, it is believed, of the known ore ground had been explored in more than the most superficial manner. At the present moment only two or three of the mines are worked. It is stated on the authority of Sr. Ortega, that 300 *montones* (of 2000 lbs.) of ore are weekly extracted from the *Neblina* and *El Rosario* veins, with a portion of rich ore from the *Amarilla* vein, only, which are worked in the Hacienda at a sufficient profit to cover the cost of the present limited workings and improvements.

4th. *All authorities agree in the statement* that the nature of the country rock at the *Cerro de Proaño* is such that the shafts and drifts require, as a rule, but little timber to sustain the pressure of the adjacent country. But it is also evident enough that this statement is not universally true, and beyond doubt, many of the old workings have become ruinous. But the fact remains on apparently good testimony, that the two great pumping shafts *Belená* and *San Francisco* are in good order, and the pumps in them in serviceable condition. From the daily work of the *San Francisco* machinery the water is supplied for the Hacienda reduction works, pumping only by day.

5th. *The great reduction works or Hacienda Nueva of Fresnillo, have a world-wide reputation, and are unequalled in extent and skillful adaptation to the Mexican method of amalgamation by Patio.* For a full and interesting description of this historic establishment the reader is referred to the account of it copied in full on p. 30 from the work of M.

Duport, already cited. Since Duport's time the crushing and grinding machinery of the Hacienda has been driven by two powerful engines of 300 horse power each, in place of animal power, as formerly.

6th. *Of the Mexican Patio Amalgamation*, as a system adapted to the special conditions of a country without water power, fuel, mechanical establishments and cheap modes of transportation, it must be said that this process, commonly attributed to *Bartolomé Medina* of Pachuca, (1557), that it has proved itself, by an experience of over three hundred years, to be well adapted to the physical conditions of the country. As M. Duport says: "When the ore is once pulverized, the silver is extracted from it by the *beneficio de Patio*, with no other apparatus than a washer and a bronze bell, with no labor beyond the treading of the pulp by the feet of men or animals, with no fuel except that required for the roasting of the *magistral* and the retorting of the amalgam, and finally without any other agents than 2 or 3 per cent. of salt and 1 to 3 per cent. of *magistral*, and with a loss of mercury, concerning which it will be necessary to enter into some details, hereafter."

As the *Patio* is now the only mode of beneficiation in use at Fresnillo—smelting not being much resorted to—it is interesting to examine somewhat critically this long established method of amalgamation. We append, therefore, the full text of M. Duport's chapter upon this subject, which is, on the whole, the best practical discussion of the *Patio*, leaving out of view for the moment, the consideration of the chemical reactions on which its value depends. See p. 72. As respects the loss of mercury in amalgamation there is much to be said which would be out of place in this general statement. But it may be said, in general, the mercury lost is never less than the weight of the silver recovered, and in the *Patio* it is generally placed at from twelve to fifteen ounces for each mark of silver produced.

7. *The loss of silver at Fresnillo* is estimated by Duport at 25 per cent. of the assay value of the ore. While this loss appears large and is much larger than the loss in the smelting of silver ores by lead under favorable conditions, it is undoubtedly true that the loss in the much more costly "Washoe process" on the ores of the famous Comstock mines in Nevada was rarely less than 30 per cent. of the assay value.

The so-called Washoe process is a combination of the Mexican arrastra and the *Patio* amalgamation, by the use of hot iron pans and settlers. An examination of the data quoted in the Appendix shows that in some years the loss of silver in the *Patio* at Fresnillo did not exceed 10 per cent.

*The Future development of the Fresnillo mines* is a problem demanding careful study for its economical and profitable solution. The water now stands probably about one thousand feet above the lowest levels in the older workings. But it by no means follows that it will be wise to proceed to unwater the lower workings except in a very gradual way. At very moderate depths the extent of mining ground accessible in the four principal areas into which the property is divided is very large and upon veins which have been only superficially explored over wide areas. Many shafts and cross-cuts appear to offer easy access to portions of the property, abundantly intersected with veins of known value waiting the skillful eye of an intelligent engineer to develop.\* Evidently the policy of the administration has not of late years been a wise one. Works of exploration have been suspended from want of means, while ores immediately available have been exhausted. This false policy will certainly bring the richest mines into *borrasca*.

Meantime the property is far from being in a condition of neglect. The immense Hacienda is in good condition and capable of handling all the ores which can be mined and of doing a large amount of custom work besides. We are assured that the steam engines and pumps are competent for all immediate demands. The enormous expense formerly incident to the transportation and erection of machinery no longer exists under the opening up of the whole of Mexico as well to Europe as to all parts of the United States by the rapidly maturing railway system.

\* On pages 8 and 9, appended to the Report of Sr. Arenas, is a full list in Spanish and English of all the veins and of the shafts and cross-cuts by which they are explored. All the names will be found (in Spanish) on the face of the accompanying map.

*RAPPORT GÉNÉRAL,**sur les Mines de Fresnillo, ou du Cerro de Proaño.*

La mine de Fresnillo est une des grandes propriétés minières historiques du Mexique, située dans l'État de Zacatecas, à quatorze lieues Nord-Ouest de la ville de Zacatecas sur le plateau Mexicain à environ 7,000 pieds audessus du niveau de la mer, et dans une région salubre, sur la ligne du Chemin de fer Central Mexicain dont les jalons ont été posés en face de la fameuse "Hacienda Nueva," ou usines de réduction de Fresnillo.

Fresnillo n'est pas une *mine* dans l'acception ordinaire du mot, mais plutôt un grand groupe de mines formant un plexus de nombreux filons argentifères qui coupent la colline connue sous le nom de *Cerro de Proaño*, qui s'élève seulement à environ 350 pieds au-dessus du niveau général de la plaine. Au pied de cette colline se trouve la ville de Fresnillo contenant 8000 habitants qui sont principalement des mineurs et des métallurgistes. L'étendue comprise dans les limites de cette propriété, est d'environ quatre milles et demi quarrés. Dans celle du "Cerro de Proaño," il y a au delà de vingt puits de creusés sur autant de veines, mais qui en percent davantage par des galeries de traverse. Le nombre de filons qui sont déjà exploités, ainsi qu'il a été constaté, se monte au dessus de cinquante. Pendant la période active des travaux, ils ont fourni 900 tonnes de minerai par semaine aux grandes usines de réduction de l'Hacienda Nueva, quoique toute la propriété n'ait pas été convenablement explorée.

La "Colline de Proaño" est entièrement couverte de débris et de rebuts provenant des anciennes exploitations commencées dit-on, peu de temps après l'occupation Espagnole, reprises environ vers le milieu du dix-huitième siècle (1750-1759), interrompues subséquemment, jusqu'aux premières années du siècle actuel, par suite des eaux qui y pénétrèrent en abondance, mais elles n'ont pas été poursuivies énergiquement ou avec profit, jusqu'après la guerre de la révolution lorsque, en 1824, l'État de Zacatecas ouvrit à l'exploitation, au moyen de concessions, et pour son propre compte, les mines de Fresnillo. Subséquemment (1832), et en conséquence de l'établissement du "Système Central," ces mines passèrent aux mains d'une Compagnie qui

partagea, avec le Gouvernement Central, nominalement à conditions égales, mais en réalité, sur une base qui donnait au Gouvernement la part du lion, ainsi que l'on le verra dans les détails présentés plus loin.

En vertu d'une ordonnance, datée le 15 Mars, 1878, les mines du Cerro de Proaño, pour une période de dix ans, sont affranchies de toute espèce d'impôts tant de l'Etat que du Gouvernement Central. Elles sont aujourd'hui en possession de Messrs. Ortega et fils, syndics de la Compagnie des mines de Fresnillo.

*CHANGEMENTS INTRODUITS PAR LE SYSTÈME DE CHEMINS  
DE FER.*

Le développement rapide, au Mexique, du système de chemins de fer, a fait disparaître bien des obstacles qui, autrefois, empêchaient les exploitations à bon marché, en apportant à l'entrée même des mines à des prix beaucoup réduits, les machines, le combustible, le sel, le mercure, les matières explosives et autres matériaux. Un examen des analyses soigneusement fait par M. Duport, des comptes ci-annexés, des frais de Fresnillo depuis le 1<sup>er</sup> Février 1838 jusqu'au 31 Janvier 1839, montre que plus de la moitié du prix de réduction, à cette époque, était comprise dans celui du mercure (34 per cent.) et du sel (17 per cent.). Ces deux articles importants et coûteux ont aujourd'hui diminué de plus de moitié, même avant l'inauguration du système de Chemins de fer.

Le combustible sous la forme de coke anglais, peut être déposé comme lest à Tampico, franc de droits, à une avance nominale sur le prix du chargement dans le pays de Galles, et transporté à la ville de Zacatecas par la ligne ferrée qui est déjà en voie de construction, et de là, à Fresnillo par le "Mexicain Central" dont elle fait partie; une distance totale d'environ 400 milles; pour fournir la force motrice aux pompes à vapeur ainsi qu'aux usines de réduction à un prix réduit comparé à celui du bois de chêne employé jusqu'ici comme combustible, et coûtant 37½ cents par quintal espagnol ce qui, mettant la corde à 3,500 livres revient à \$13 par corde.

La carte ci-jointe, indique les différentes lignes de Chemins de fer projetées jusqu'à présent, dans leur état actuel de construction. Un coup d'œil suffira pour montrer que Fresnillo se trouve sur le tracé principal du Mexicain Central, le liant au Nord aux États-Unis, et au Sud à la ville de Mexico, et au port de Tampico sur le Golfe du Mexique. Par un embranchement de la même ligne, déjà en pleine opération, Guaymas, sur le Golfe de

Californie est aussi en communication avec Fresnillo, et, ultérieurement, la ligne de Sinaloa depuis Mazatlan et Culiacan, liera ces ports de mer à Durango et Zacatecas.

Dès 1838, l'usage des pompes à vapeur à Fresnillo, avait réduit de quatre cinquièmes le prix du dessèchement des mines comparé à l'ancien système de *Malacates* ou treuils mus par des chevaux, employant 500 hommes et 2,000 chevaux.

Un combustible meilleur marché, non-seulement diminuera le prix de tous les travaux à la machine que les mines et les usines de réduction exigent, mais, très probablement, mettra les Directeurs à même de se servir des fonderies pour le genre de minerai appelé rebelle qui ne se traite pas aussi bien dans le "*Patio*." Le transport par chemins de fer apportera facilement, du Sud et du Nord, où ils sont abondants, les minérais de plomb et autres fondants basiques, contenant une certaine quantité d'argent, rendant ainsi aisée et économique la fonderie du minerai rebelle.

Les grands perfectionnements qui ont été faits depuis vingt-cinq ans dans le percement des roches dures ainsi que dans les fonderies, dans les matières explosibles puissantes, dans les appareils à concentrer, dans les machines à broyer les roches, dans les pulvérisateurs et autres machines servant à l'exploitation des mines, seront bientôt toutes mises à la portée de Fresnillo par les chemins de fer, et aideront à révolutionner les vieilles méthodes, en mettant une classe considérable de minerai, autrefois considéré comme d'une teneur trop inférieure pour être retiré de la mine et travaillé avec profit, au rang des réserves précieuses dont le Proaño est connu pour en contenir une quantité considérable.

#### *PRODUCTION ANNUELLE DES MÉTAUX PRÉCIEUX DU MEXIQUE.*

La production actuelle des métaux précieux pour l'année 1880-81, annoncée officiellement, est de \$29,713,355, non comprises les vastes quantités obtenues par les explorateurs, mais seulement ce qui est parvenu à la connaissance des fonctionnaires du Gouvernement Mexicain.

La moyenne de la quantité trappée de 1874 à 1879, inclusivement, d'après les rapports officiels des sept Monnaies réunies, qui sont toutes placées sur la ligne du Chemin de fer Mexicain Central, se monte à \$19,132,120.55. De cette somme, la Monnaie de Zacatecas a produit, pendant les années précitées, une moyenne de \$4,950,706.30. Depuis 1880, elle donne annuellement près de six millions, ce qui est la plus grande quantité provenant d'aucune autre Monnaie de la République.

## xxviii

La somme totale frappée au Mexique, de 1690 à 1855, inclusivement, (176 ans) est établie par M. P. Laur, Ingénieur français, dans les "Annales des Mines" (loc. cit.) comme suit:

Argent,	- - - - -	\$2,194,978,639
Or,	- - - - -	103,071,903
<hr/>		\$2,298,050,542

Cette somme immense qui représente en moyenne, un peu plus de \$13,000,000 par an pour toute cette période, est bien loin de donner le grand total du métal produit par le Mexique jusqu'à la date mentionnée, et qui réuni, n'est probablement pas moins de trois mille millions de dollars.

Le fait matériel est que, depuis le rétablissement de l'ordre au Mexique, le produit total a augmenté constamment, et ce n'est pas trop anticiper que de croire qu'il égalera bientôt la quantité retirée avant la chute de la domination Espagnole, époque où elle dépassait cinquante millions, annuellement.

Les possibilités futures du rendement des métaux précieux du Mexique sont telles, qu'elles sont de nature à éblouir même l'imagination. Jusqu'à présent, on a peu fait en vue de fondre la quantité de minerai de plomb argentifère que l'on sait être immense de même que le minerai de cuivre argentifère et aurifère. M. Duport termine son rapport sur la production des métaux précieux du Mexique, par les observations suivantes:

"Le manque de capitaux, de tranquillité politique, de population et de culture dans le nord-ouest de la république, de connaissances scientifiques suffisamment étendues, et enfin, le haut prix du mercure, sont les causes qui s'opposent au développement de la production des métaux précieux au Mexique. Ces causes exercent encore leur influence fatale pendant plusieurs années, en empêchant que la production n'atteigne et ne dépasse le chiffre auquel on l'a vue s'élever au commencement du siècle.

"Mais on ne saurait leur trouver un caractère durable; elles ne sont que temporaires, et doivent, à la longue, être neutralisées d'abord, et dominées plus tard, par des forces autrement imposantes, l'abondance du minerai, et les progrès des sciences qui reculent chaque jour les bornes de la puissance de l'homme. Le temps viendra, un siècle plus tôt, un siècle plus tard, ou la production de l'argent n'aura d'autres limites que celles qui lui seront imposées par la baisse toujours croissante de sa valeur."

L'ouverture du Mexique par le système des Chemins de fer, était un événement que M. Duport, en 1843, n'avait pas prévu; autrement, il aurait certainement compris un facteur aussi important, destiné (pour nous servir de sa comparaison) à amener le résultat qu'il avait prédit "un siècle plus tôt."

*DONNÉES RELATIVES À L'ANCIENNE HISTOIRE DES MINES  
DU CERRO DE PROAÑO.*

Les données concernant l'ancienne histoire des mines de Proaño ou Fresnillo, sont abondantes et authentiques; elles comprennent ses périodes successives d'activité avant l'introduction des appareils hydrauliques à vapeur pour dessécher les mines et subséquemment, et la construction de la fameuse Hacienda pour le traitement (*beneficio*) du minerai. Les traductions de ces documents sont ci-annexées et, ce n'est qu'après les avoir lues attentivement que l'on aura une juste idée de la nature et de l'étendue de cet immense *stockwerk*, de l'importance des travaux qui ont été entrepris pour son exploitation et d'autres du même genre plus grands encore, qui attendent l'ère du nouvel ordre de choses, qui ouvrira ces régions aux méthodes modernes par le système des chemins de fer.

*RAPPORT DE DON PASCUAL ARENAS, 1859.*

Sefñor Arenas, de l'Ecole Nationale des Mines de Mexico et Professeur d'Exploitation à l'Ecole Pratique de Fresnillo, d'après les études de ses élèves, a préparé une brochure compréhensible et satisfaisante, sur la région minière de Fresnillo, accompagnée de la seule carte que nous possédons, montrant la direction et l'allure des filons avec les sections de la formation et des travaux. L'étude de cette carte minière et géologique, ainsi que des données contenues dans le Rapport et d'autres pièces qui seront bientôt mentionnées, est très intéressante car elle démontre le fait qu'une grande quantité de terrain minier connue pour être coupée par de nombreux filons d'argent, n'a pas été explorée, si toutefois ils l'ont été, à plus de 40 brasses de profondeur.

Ce mémoire important porte la date de Novembre, 1859, pendant l'administration prospère de Don José Gonzales Echeverria, qui dirigea, sauf pendant une courte interruption, les affaires de Fresnillo durant vingt-sept ans jusqu'à sa mort, en 1864. Nous aurons l'occasion de référer encore à cet homme éminent. Avant l'organisation, en 1835, de la Compagnie florissante de *Zacatecano-Mexicana*, la Législature de l'État de Zacatecas, par un décret approuvé en 1830, prit la direction des Mines de Fresnillo, alors abandonnées et remplies d'eau, et les exploita au moyen du travail de forçats amenés de toutes les parties de l'État. Nous n'avons qu'un exposé général avec quelques détails de ces efforts qui auraient, dit ce

xxx

document, obtenus de bons résultats. Ainsi, il paraît, d'après le rapport de Messrs. Auld et Buchan, pour l'année, à partir du 30 Novembre, 1832, jusqu'au 30 Novembre, 1833, qu'il y a eu un profit de \$149,000 sur le produit total d'un peu plus de un million et demi de dollars. Les difficultés causées par l'eau étaient trop difficiles à surmonter pour les treuils à chevaux (*malacates*) qui, à cette époque, étaient le seul moyen de dessécher ces mines; en outre, les troubles politiques contribuèrent à diminuer considérablement le nombre des ouvriers employés à l'exploitation et à l'extraction. Ce mémoire est donné en entier, page 1.

*RAPPORT DE MESSRS. AULD ET BUCHAN.*

Le document le plus important qui vient après, donnant l'histoire des Mines de Fresnillo, est celui qui a été publié à Londres, le 4 Juillet, 1834, par Messrs. Auld et Buchan, Ingénieurs de Mines, Anglais, qui ont résidé pendant longtemps au Mexique et parfaitement familiers avec l'histoire de Fresnillo ainsi qu'avec les méthodes Mexicaines de travailler les mines. Ce mémoire, intitulé "*Notice of the Silver Mines of Fresnillo*," fût traduit en espagnol par ordre de l' Honorable Congrès, et réimprimé par Pedro Piña, Zacatecas, 1835. N'ayant pu découvrir un exemplaire de l'original, en anglais, une traduction complète de l'édition espagnole est donnée p. 11. La carte qui est mentionnée dans le texte, a été perdue. Mais cela ne tire à aucune conséquence, car nous en possédons une de date plus récente, dressée par Don Pascual Arenas, déjà cité. Ce document mérite d'être lu attentivement, d'autant plus qu'il se rapporte à l'histoire de ces mines remarquables. Il est particulièrement intéressant comme étant l'exposé sincère de deux ingénieurs Anglais tout à fait compétents et expérimentés, et, depuis longtemps, habitués à diriger des exploitations importantes de mines. Les faits qu'ils présentent sont d'un grand intérêt, car ils font voir le contraste favorable qui résulta des efforts (1830-1833) du Gouvernement Mexicain, en vue de réhabiliter les mines de Fresnillo, comparés à ceux de quelques Compagnies Anglaises, des sommes gaspillées et des pertes considérables qu'elles éprouvèrent, à cette époque, pour rouvrir certaines vieilles mines célèbres Mexicaines qui ne répondirent pas généreusement à leur attente, ni ne donnèrent l'équivalent des sommes dépensées inutilement. Les notes annexées au rapport de Messrs. Auld et Buchan, fourniront tous les détails nécessaires sur ce sujet.

*M. ST. CLAIR DUPORT.*

Cet éminent ingénieur de mines français, qui a résidé pendant de longues années au Mexique, nous a donné un rapport complet sur les Mines de Fresnillo, dans son important traité "De la Production des Métaux Précieux du Mexique, 1843," et dont plusieurs passages en traduction, sont ci-annexés. A l'époque où Duport écrivait ce précieux document, la vapeur avait remplacé la force de chevaux pour pomper l'eau hors des mines de Fresnillo, et "l'Hacienda Nueva" avait été construite par Sr. Anitua à un prix dépassant \$340,000 et était en pleine activité sous l'habile direction de Don José Gonzales Echeverria. Le coût du mercure, du sel, du *magistral* et du combustible, se trouvait encore élevé, et les frais de force animale employée dans l'exploitation se montaient à 12 pour cent. du prix total du traitement pour produire un marc d'argent. Le travail soigneusement préparé sur le prix complet de cette méthode et sur la perte de mercure par le procédé *Patio*, tel qu'il a été appliqué à Fresnillo, est très instructif. Relativement au *Patio* Mexicain, quelques renseignements détaillés qui sont relevés aussi du Rapport de M. Duport, sont cités plus loin.

*RAPPORT DE DON JOAQUIN M. RAMOS.*

Sr. Ramos, ingénieur éminent, alors Directeur des Mines de la Compagnie de Proaño, et résidant aujourd'hui à Zacatecas, présenta, en 1865, un rapport succinct mais détaillé, sur la condition des mines de Proaño à cette époque et depuis la mort d'Echeverria. Ce document sera lu avec intérêt, car il est, (sauf le Rapport d'Ortega) le témoignage le plus récent et le plus authentique que nous ayons, relativement à l'état des mines tant alors que maintenant. A l'exception des niveaux supérieurs, les travaux opérés sur les autres, ont été très limités. Pour un ingénieur, il est évident que Sr. Ramos a été restreint par suite d'une fausse économie de ses Directeurs, pour étendre l'exploration sur de nouveaux terrains plus profitables, par le manque de moyens convenables d'assurer solidement les puits et les niveaux exigeant une surveillance spéciale, par le manque d'appareils ventilateurs, ainsi que de combustible et, conséquemment de force motrice pour retirer l'eau hors des niveaux inférieurs des mines. Malgré toutes ces difficultés, il est clair, d'après un examen attentif de ses données, qu'il reste encore une ample réserve de bon minerai qui produirait un résultat profitable et immédiat, et mettrait à découvert une quantité considérable de terrain inexploré à des profondeurs modérées, dans les limites du Cerro

de Proaño, sans recourir à la nécessité, d'ici à longtemps, de creuser plus en avant; pourvu, toutefois, que quelques uns de ces nombreux puits, comparativement peu profonds, soient percés avec jugement aux endroits que Sr. Ramos indique comme contenant des gisements presque intacts de riche mineraï. Mais ses conseils ne furent évidemment pas suivis, puisqu'en 1867, un autre ingénieur, Augustin Pró, faisait un rapport à la Compagnie, sur la hauteur de l'eau qu'il y avait dans le mine de Beleña. En examinant ce document (p. 57.) on constatera que le changement regrettable d'administration avait déjà causé une diminution dans la production des mines, et entraîné de grandes dépenses pour les remettre à sec. Ce fâcheux état de choses alla de mal en pire jusqu'en 1872, lorsque toute la propriété revint de nouveau à l'État.

#### *ÉVÉNEMENTS PUBLICS DÉSASTREUX, 1857-1867.*

La soi-disant guerre de réforme, la confiscation des biens ecclésiastiques, l'occupation française avec toutes ses conséquences déplorables, accablèrent ce malheureux pays depuis 1857 jusqu'à 1867. La période de dépression dans les affaires des mines de Proaño, l'envoi en exil de l'éminent Echeverria, et la mauvaise administration des mines qui en fût le résultat, tout donne une juste idée des désastres qui suivirent, à cette époque, l'ébranlement général dans les affaires publiques et privées.

#### *RAPPORT DÉTAILLÉ DES AFFAIRES ET DES DIVIDENDES DES MINES DE PROAÑO, 1841-1849.*

Un rapport détaillé des Affaires des Mines de Proaño, daté le 10 Octobre 1844 (voir p. 59 à 65) sera considéré intéressant vu l'exactitude avec laquelle chaque partie, même la plus simple, des matériaux employés, a été enregistrée pendant cette longue période. L'extrait suivant donne les principaux résultats de neuf années d'exploitation.

Les mines ont produit une somme totale de,	\$18,641,194.36
Les frais d'extraction, de réduction et d'administration ont été,	17,888,718.22
Somme distribuée comme profits,	\$ 1,552,496.14
Cette somme nette a été repartie comme suit:	
Prêt au Gouvernement Suprême,	\$1,099,194.00
Paient des dettes du Gouvernement,	193,518.00
Profits, soi disant nets, payés au Govt.,	499,665.75 \$1,792,377.76
Laissant un déficit apparent, pour 9 ans, de,	\$239,901.61

xxxiii

Une somme excédant un million de dollars doit être ajoutée aux profits ci-dessus, donnés par les mines et dépensées en améliorations permanentes qui, encore aujourd'hui, ont de la valeur.

Ces améliorations sont:

Prix de l'Hacienda Nueva,	\$340,132
Prix de deux Machines à vapeur complètes,	504,860
Prix de différentes constructions nouvelles ou réparées,	68,625
Prix de deux machines à vapeur supplémentaires (en parties),	100,865
Prix des améliorations permanentes payées avec les profits des mines,	\$1,014,485
Profits précédents,	1,552,496
Profits de neuf années d'exploitation,	\$2,566,981

*DIVIDENDES PAYÉS AVANT 1850.*

Du 18 Décembre 1841 au 14 Novembre 1849, inclusivement, les mines de Proaño ont payé en dividendes \$3,046,890.61 soit une moyenne de \$385,000 par an. Cette période est en partie, celle comprise dans le Rapport qui vient d'être présenté. Les chiffres sont donnés en détail, p. 64 et 65.

*CAUSES DE LA DIMINUTION DANS LA PRODUCTION DU  
MÉTAL À PROAÑO, APRÈS 1850.*

De 1853 à 1862, inclusivement, une période de dix ans, embrasse la majeure partie de celle des grands troubles politiques du Mexique, déjà mentionnés, pendant laquelle les travaux de recherches des mines furent sérieusement interrompus tant à Proaño que dans d'autres localités du pays. De vastes quantités de minerai de faible teneur qui, autrefois, avaient été rejetées, furent alors extraites et traitées avec perte; et l'on affirme qu'on apportait si peu de soins dans le choix du minerai, après l'exil d'Echeverria, que des quantités considérables de matériel, comparativement d'aucune valeur, furent soumises au traitement (*beneficio*) diminuant, par ce fait, la moyenne de bon minerai audessous de la limite des profits. C'est pourquoi nous ne sommes pas surpris des chiffres que nous relevons d'après les tableaux donnés p. 66. Pendant les dix années précédentes, la masse de minerai extrait, était de 3,092,530<sup>8</sup> cargas = 463,879.6 *montones*, ou tonnes, et celle qui a été traitée s'élevait à 452,264.8 *montones*, ou 11,614.8 tonnes que la quantité extraite, voir p. 66, le rapport détaillé d'où ces chiffres sont résumés.

Le prix total de l'extraction à été \$10,903 par *monton*, dont \$8,531 pour creuser la mine et \$2,372 pour les travaux hydrauliques.

Le prix du procédé s'est monté à \$11,170 par *monton*, donnant un total pour l'extraction et le traitement du mineraï, égal à \$22,073 par *monton*. Le rendement moyen des 452,264.8 *montones* soumis à ce procédé, a été de \$21,725 par *monton*. Ainsi, il paraît donc que le résultat de ces dix années, a été, en moyenne, une perte de 34.8 cents par *monton*, soit, environ \$160,000.

Pendant cette période, la production totale des mines a été de \$9,825,595.68.

Si ce résultat restait inexplicable par les raisons déjà présentées, on pourrait naturellement supposer qu'il doit être attribué à l'épuisement des minéraux plus riches retirés durant la décade précédente. Mais il semble, d'après les données fournies par le rapport soigneusement préparé de Sr. Ramos, ci-dessus mentionné, que le mineraï n'avait pas été extrait des niveaux inférieurs; et, qu'en 1865 la quantité d'une teneur meilleure propre au *Patio*, était importante et en augmentation, malgré la négligence de la Direction après l'exil d'Echeverria. On a même affirmé qu'il y avait actuellement un certain nombre de personnes influentes qui étaient décidées à déprécier, dans un but inavouable, la valeur de la propriété, en réduisant, intentionnellement, le grade du mineraï fourni à l'Hacienda.

#### *RAPPORT DE MESSRS. ORTEGA ET FILS.*

Ce rapport est daté de Fresnillo, le 24 Mars 1881, et fût présenté alors, aux actionnaires de la "Mining Company of Fresnillo," par Messrs. Ortega et fils, en leur qualité de Syndics (*Assignees*) de la propriété. Ce document contient des renseignements précieux relatifs à la condition actuelle et aux travaux en opération tant des mines que de l'Hacienda. Il y est dit que trois cents tonnes de mineraï par semaine, sont maintenant retirées de trois des mines pour être traitées à l'Hacienda, et dont le produit suffit à défrayer toutes les dépenses d'entretien et de dessèchement. Messrs. Ortega certifient que tout est en bon ordre à Proaño et à l'Hacienda. Les pompes fonctionnent seulement pendant le jour pour fournir l'eau nécessaire aux usines de réduction; limitant ainsi les travaux de recherches dans les niveaux supérieurs à un nombre restreint de filons. Les machines à vapeur qui mettent en mouvement les pilons et les arrastras pour la réduction, remplacent aujourd'hui avec économie les nombreux animaux et les palefreniers qui en prenaient soin, employés autrefois à ce même travail. Voir p. 51 etc.

*REMARQUES DE JOSEPH BURKART, SUR LES MINES DE  
PROAÑO, DANS SON "REISEN IN MEXICO."*

Le caractère général minéralogique, géologique et métallurgique des roches et des minéraux du Cerro de Proaño, ainsi que celui des plaines adjacentes, est si clairement et si complètement établi dans les différents mémoirs déjà cités, qu'il est à peine nécessaire de multiplier les témoignages sur ces points. Toutefois, le lecteur peut consulter avantageusement les opinions de feu Joseph Burkart, éminent ingénieur allemand, qui, pendant longtemps, demeura au Mexique (1825-1834) chargé de l'exploitation de la mine de Bolaños, située sur la Veta Grande, à Zacatecas, et, qui, dans son "Reisen in Mexico," a donné le résultat de ses observations, faites particulièrement à Zacatecas. Le texte concernant Fresnillo présenté ci-joint, sera lu avec attention, comme étant le témoignage sincère d'un des observateurs les plus compétents et expérimentés et surtout familier, par suite d'études approfondies, avec les minéraux de Zacatecas qui, aujourd'hui, nous intéressent le plus.

*CONCLUSIONS GÉNÉRALES FORMÉES D'APRÈS LES TÉMOIGNAGES RÉUNIS DE TOUTES LES AUTORITÉS COMPÉTENTES, QUI ONT DONNÉ DES RÉSULTATS UTILES, ET DONT PLUSIEURS SONT MAINTENANT PUBLIÉS POUR LA PREMIÈRE FOIS.*

Selon les témoignages unanimes de tous les auteurs et des autorités compétentes dont les rapports sont cités ici, les faits suivants peuvent être considérés comme étant bien établis.

1°. Le système des filons d'argent explorés à Fresnillo, de même que ceux du Cerro de Proaño et leur extension dans les plaines adjacentes, se rapporte aux formations géologiques et lithologiques dans lesquelles se trouvent toutes les mines fameuses de Zacatecas, de Guanajuato, Guadalajara, San Luis Potosí, etc., etc. Ces filons se composent tous de veines fissures dans ce que l'on nomme "*Grauwacke*," et dans l'ardoise argileuse métamorphique, probablement de l'époque Dévonienne. Ceux de Fresnillo

sont très nombreux mais généralement pas très larges; cependant, par une étrange singularité qui sera bientôt expliquée, ils sont exploités sur une étendue plus vaste que la largeur des fissures qu'ils remplissent.

2°. Les filons de Fresnillo contiennent trois sortes de minéraux connus sous les noms de "*Los Colorados*," "*Los Negros*" et "*Los Azulaques*."

a. *Los Colorados*, minéraux rouges, sont caractérisés principalement par l'argent natif, le chlorure d'argent ou Chlorobromure (*plata verde*) mélangés d'oxyde de fer rougeâtre et de gangue quartzeuse, mais rarement de restes de minéraux non-oxidés. Bref, le minéral rouge marque la zone de décomposition influencée par l'atmosphère et son humidité, et la profondeur à laquelle elles pénètrent, varie considérablement selon les différentes veines. *Los Colorados* à Fresnillo ont donné une moyenne d'environ  $3\frac{1}{2}$  onces d'argent pour cent livres de minéral brut.

b. *Los Negros*, ou minéraux noirs consistent essentiellement de gangues quartzeuses contenant des sulfures noirs d'argent, principalement l'argentite et l'argent sulfuré fragile avec de l'argent rouge et rouge clair, de l'argent natif, des pyrites de fer, rarement du cuivre, et des sulfures de zinc et de plomb, ces dernières encore plus rares que les pyrites de fer et de zinc, qui, dans certains filons (e. g. San Pedro) sont trop fréquentes pour le bien de la mine, puisque cette catégorie de minéral étant plus pauvre en argent, n'est essentiellement qu'un minéral de fonderie. *Los Negros*, en somme, ne sont que des minéraux ayant échappé à l'action de la décomposition qui, autrepart produisit "*Los Colorados*." La valeur de *Los Negros* à Fresnillo peut être évaluée avec justice d'après l'autorité de Burkart et de Duport, à 4 onces par 100 livres de minéral.

c. "*Los Azulaques*" ou minéraux bleuâtres, appartiennent particulièrement aux filons d'argent du Cerro de Proaño. Burkart affirme distinctement qu'ils ne se trouvent pas à Zacatecas, e. g. sur la Veta Grande ou Malanoche. Ils se composent principalement des mêmes minéraux qu'on rencontre dans les filons adjacents, et qui sont distribués dans les roches du pays à une distance variant entre  $\frac{1}{2}$  vara (16") et 1 vara (32") de la veine. Le long de ce parcours, on trouve la roche du pays imprégnée de pyrites de fer, d'argentite et d'argent natif et corné en très petites parcelles. L'argent natif et corné se rencontrent en couches minces à la surface des fissures des roches, l'argent natif présente un lustre métallique brillant qui, avec le *plata verde*, guident le mineur pour savoir s'il serait profitable ou non, de briser les roches. Un mineur inexpérimenté serait disposé à rejeter la roche qui, à la pulvérisation et au lavage à la cuiller de corne ou bassin de mineur, donnerait une quantité importante de parcelles métalliques consistant principalement d'argent natif et corné. La moyenne des

*Azulaques* est estimée, par Burkart, à 3 onces par cent livres de mineraï. C'est la rencontre fréquente de cette riche imprégnation des roches, en dehors du filon même, qui distingue les mines du Cerro de Proaño comparées aux autres régions minières découvertes au Mexique jusqu'à présent, et qui fait que l'exploitation de filons si étroits est profitable, lesquels sans cette heureuse circonstance, ne pourraient être extraits avantageusement.

Une question intéressant à étudier, lorsque les anciens travaux de Fresnillo seront rouverts, sera celle de savoir si l'on peut y encore extraire des *Azulaques*, à assez bon marché; car, avec les moyens modernes de concentrer et de traiter le mineraï, ces *azulaques* pourront facilement être mis en état de rapporter un profit par le *Patio*, quoiqu' avec les méthodes lentes et coûteuses du traitement mécanique qui y étaient exclusivement employées autrefois, ils tombèrent audessous d'un rendement d'argent rémunératif et furent négligés en conséquence. Si cette suggestion était appuyée par des expériences incontestables et probantes, la quantité de mineraï de ce genre se trouvera être probablement très grande, et utilisée à un prix très modique. Heureusement, qu'à Fresnillo, l'abondance d'eau qui est pompée des mines mêmes, est assez suffisante pour tout plan de concentration par l'irrigation qui serait adopté.

3°. Les réserves de Mineraï à Fresnillo sont amples. On croit qu'il n'y a pas plus d'un tiers du terrain minier connu, qui a été exploité autrement que d'une manière superficielle. Au moment actuel, deux ou trois mines seulement sont travaillées. D'après l'autorité de M. Ortega, 300 *montones* (de 2,000 livres) de mineraï sont extraits par semaine des filons de la "Neblina" et de "El Rosario," ainsi qu'une quantité de riche mineraï de la veine de "l'Amarilla," qui sont toutes traitées à l'Hacienda, et donnent un profit suffisant pour subvenir aux dépenses des améliorations et des travaux à présent restreints.

4°. Toutes les autorités s'accordent dans l'opinion que la nature de la roche du pays au Cerro de Proaño est telle, que les puits et les galeries n'exigent, en général, que peu de bois de charpentes pour soutenir le poids des roches environnantes. Il est de même évident que cette opinion n'est pas universellement vraie, car, sans aucun doute beaucoup d'anciens travaux sont devenus ruineux. Mais le fait existe, basé apparemment sur des témoignages dignes de foi, que les deux grands puits à pompes, *Belená* et *San Francisco*, sont en bon état, et que les appareils hydrauliques qui s'y trouvent le sont aussi et prêts à servir. Le fonctionnement, pendant le jour seulement, des machines de *San Francisco*, suffit à fournir l'eau nécessaire à l'usine de réduction de l'Hacienda.

5°. Les grandes usines de réduction, ou *Hacienda Nueva* de Fresnillo,

jouissent d'une réputation universelle, et sont sans égales tant par leur étendue que pour leur habile adaptation à la méthode mexicaine d'amalgamation par le *Patio*. Pour une description complète et intéressante de cet établissement historique, le lecteur est référé au récit copié *in extenso*, p. 30, etc., tiré de l'ouvrage de M. Duport, déjà cité. Depuis l'époque où l'auteur l'écrivait, les machines à broyer et les pulvérisateurs de l'Hacienda fonctionnent par deux puissante machines à vapeur de 300 chevaux au lieu de la force animale employée autrefois.

6°. De l'amalgamation Mexicaine dans le *patio*, comme système adapté aux conditions particulières d'un pays privé d'eau comme force motrice, de combustible, d'usines et de moyens de transports à bon marché, on peut dire que ce procédé, généralement attribué à Bartolomé Medina, de Pachuca (1557) après une expérience de plus de trois cents ans, convient bien aux conditions physiques du pays. "On voit," dit M. Duport: "Qu'une fois le minerai tritiqué, l'argent est extrait de ses gangues par le *beneficio de patio*, sans aucun appareil autre qu'un lavoir et une cloche de bronze, sans autre main-d'œuvre que le foulage des boues par le pied des hommes ou des animaux, sans autre combustible que celui nécessaire au grillage du *magistral* et à l'évaporation de l'amalgame, et enfin, sans autre ingrédient que

2 à 3 pour cent. de sel,  
1 à 3 de magistral,

et avec une quantité de mercure perdue, sur laquelle il est nécessaire d'entrer dans quelques détails."—voir Duport, p 117.

Considérant que le *Patio* est le seul moyen employé à présent à Fresnillo, la fonderie n'étant pas beaucoup en usage, il est intéressant d'examiner, au point de vue critique, cette méthode d'amalgamation utilisée depuis si longtemps. Nous ajoutons donc le texte entier du chapitre de M. Duport sur ce sujet qui, somme toute, est la meilleure discussion pratique du *Patio*, mettant de côté, pour le moment, la considération des réactifs chimiques dont sa valeur dépend. Voir p. 72. En ce qui concerne la perte de mercure dans l'amalgamation, il y aurait beaucoup à dire mais qui serait, déplacé dans ce rapport général. Toutefois, on peut constater, qu'ordinairement, le mercure perdu n'est jamais moins du poids de l'argent obtenu, et dans le *Patio*, il est, en moyenne, évalué à 12 ou 15 onces pour chaque marc d'argent produit.

7°. La perte d'argent, à Fresnillo, est estimée par Duport à 25 pour cent de la valeur du minerai obtenu par essai. Quoique cette perte, parait être grande, et qu'elle est réellement plus grande que celle qui résulte de la fonte du minerai par le plomb, dans des conditions favorables; il est en outre, incontestablement vrai que celle qui est faite par le "procédé Washoe,"

xxxix

bien plus coûteux, et appliqué aux minerais des fameuses mines Comstock, du Nevada, était rarement moins de 30 pour cent de la valeur d'essai. Cette dernière méthode, appelée "Washoe," est une combinaison de l'arrastra Mexicaine et de l'amalgamation du *Patio*, par l'usage des bassins à porphyriser, construits en fer et chauffés par la vapeur, et des cuves à déposition. Un examen des données citées dans l'appendice, montre que, pendant quelques années, la perte d'argent dans le *Patio* de Fresnillo, n'a pas dépassé 10 pour cent.

Le développement futur des mines de cette localité, est un problème qui demande une étude sérieuse pour en donner une solution économique et profitable. L'eau se trouve actuellement à environ mille pieds audessus des plus bas niveaux dans les plus anciennes exploitations. Mais il ne s'en suit pas qu'il serait prudent de continuer à dessécher les exploitations inférieures sauf d'une manière très graduelle. A des profondeurs modérées l'étendue des terrains miniers accessibles dans les quatre principaux districts qui divisent la propriété, est très grande, et sur des filons qui n'ont été que légèrement explorés sur de larges surfaces. Beaucoup de puits et de galeries de traverse paraissent offrir un accès facile dans des parties coupées abondamment par des filons d'une richesse connue, et qui attendent l'œil exercé d'un ingénieur intelligent pour être développées. Evidemment dans ces dernières années, la manière de voir de l'administration n'a pas été prudente, car des travaux de recherches ont été suspendus faute de moyens, pendant que le mineraï, d'un rapport immédiatement avantageux était épuisé. Cette fausse politique conduira sans doute, les mines les plus riches à la "borrasca."

En attendant, la propriété est loin d'être négligée. L'immense Hacienda est en bon état et capable de traiter tout le mineraï que l'on peut extraire, et entreprendre, en outre, une quantité considérable de travaux de commande. On nous assure que les machines à vapeur et les pompes suffisent aux besoins actuels. Les frais énormes qu'entraînait, autrefois, le transport et l'érection des machines, n'existent plus depuis que tout le Mexique, est ouvert à l'Europe et aux États-Unis par le système de voies ferrées, qui tend à se perfectionner rapidement.

Page 8 et 9 ajoutées au Rapport de Sr. Arenas est une liste complète en anglais et en espagnol, de tous les filons et des galeries de traverse, par lesquelles ils sont explorés. Tous ces noms sont en espagnol, sur la carte, en tête de ce mémoire.



*GEOLOGICAL AND MINERALOGICAL DESCRIPTION  
OF THE MINING REGION OF FRESNILLO*

By DON PASCUAL ARENAS,

*Prof. of Exploitation in the Practical School of the National School of Mines, Mexico, Nov. 1859.*

INTRODUCTION.

Ever since the establishment of the School of Practical Mining at Fresnillo in the year 1854, it has been the custom to dedicate some fifteen or twenty days at the beginning of each year's course of study, to the investigation of the geological formation of the basin of Fresnillo; and now that some data have been accumulated by means of which this mining district can be better understood, I will attempt to give a description of it. I can not pretend, however, that it will be a complete study of the whole basin, inasmuch as the extent hitherto well reconnoitered, does not exceed two and one half leagues with the *Cerro de Proaño* as a center. Even the immediate vicinity of the *Cerro* itself has only been superficially explored, because the necessary work of the School has not permitted the undertaking of an exploration on such a scale as would be desirable in order to frame reliable theories.

This monograph will be divided into three separate parts. The first part will embrace the physical aspect of the region and some data concerning its meteorology; the second part will embrace the geological description of the ore-bearing rocks of Fresnillo and Plateros, together with the relations which exist between them and the rocks of the adjacent region; and the third part will treat of the mineralogical character of the veins of Fresnillo—or rather, it will be a description of its system of veins.<sup>(1)</sup>

(1) In the map following this paper will be found a plot of the veins, sections of the *Cerro de Proaño*, and a sectional geological sketch of Fresnillo and Plateros, preparatory to the publication of the third part of this monograph.

[The text of the third part of this monograph has not come to hand.]

## PART I.

*PHYSICAL ASPECT AND METEOROLOGY OF THE BASIN OF  
FRESNILLO AND PLATEROS.*

The great valley of Fresnillo is more than 25 leagues long from North to South, and from 20 to 22 wide from East to West. It is bounded on the North by the mountain ranges of Chapultepec and Tetillas, on the East by the Tinaja and Zacatecas ranges, on the South by the Zacatecas range and the range of "los Organos de Jerez," and on the West by the range of Valdecañas and that of "los Pitos de Abrego."

The monotony of the valley is broken by a few ranges of hills of little elevation, which are generally rounded if composed of sedimentary rocks or basalt, but precipitous if they are capped with porphyry.

The valley also presents many depressions in which waters accumulate, forming lakes from whose shores salt is obtained.

With reference to the hills above mentioned, we shall confine ourselves to those in the immediate vicinity of Fresnillo and Plateros, which are the most important. About Fresnillo, six of these little hills form a sort of semi-circle around the elevation known as the "*Cerro de Proaño*," which has an elevation of scarcely 100 meters above the level of the City of Fresnillo, which last is on the general level of the plain. The "*Cerro de Proaño*" itself has a circumference of about 3000 metres, with gentle and very regular slopes. In this hill, viz: the "*Cerro de Proaño*," are concentrated the argentiferous veins of this celebrated mining region, which was long ago worked to the depth of 80 to 90 metres, and which since the year 1830 has been worked to the depth of 400 metres—which is the depth of the bottom of the workings in the 14th "general level" in the *Belená* mine.

Miners generally are much surprised at the slight elevation of "*Proaño*," when they consider the vast quantity of ore which it has produced, the unquestionable evidence of which is to be seen in the numerous great dump piles which cover the whole of the northeast and southeast slopes of this little mountain.

But this surprise comes from the fact that we are accustomed to connect the richness of ore-bearing rocks with the steepness and height of the mountains in which they occur. This opinion of miners, however, that as a general rule, high and steep mountains are the only places where rich ore is to be looked for, is contradicted by many facts throughout the Republic of Mexico.

The principal ridges of "*Plateros*" are those of "Las Animas, San Demetrio, Buenos Aires and La Leona," which form an amphitheater well closed towards the east, but which opens towards the west, giving exit to a plain more than a league long, into which the veins of this district extend. These veins have hitherto only been superficially worked in the plain, and in the hills of "La Leona" and "La Cata de Plata," to the depth of 100 metres. It is more than ten years

since the mines of "Plateros" have been abandoned, and if any of them have been worked within that time, it has been done without capital and without profit.

The mines of "Valenciana" and "La Leona" were previously worked by an English Company, who spent in preparatory works over \$70,000; and those of "La Cata de Plata," and "San Onofré," were also worked by the "*Proaño*" Company, which last having succeeded in recovering the capital spent in their opening up, finally abandoned them on account of the extreme hardness of the rock which encloses the "*Cata de Plata*" vein.

The "Plateros" mines therefore remain as an ultimate resource for the Fresnillo Co., who, having a large capital employed in steam engines, reduction works, and materials and supplies of various kinds, cannot abandon all these, in case the Proaño veins should give out, without exploring those of Plateros, which up to the present time are almost virgin in spite of the fact that they were worked many years before the others. The original name of this mining property was "San Demetrio de los Plateros."

Vegetation is scarce in the Fresnillo valley by reason of the light rain-fall and the lack of springs and rivers. But timber is plenty in the mountain ranges of Valparaiso, San Mateo, Abrego and Chapultepec, which furnish eight species of pine, six of oak and two of mimosa, whose wood is employed in the construction of machines, the timbering of the mines, and as fuel for the four large steam engines employed in pumping and grinding. A considerable quantity is also converted into charcoal for the use of iron foundries and forges, the retorting of the silver, and for domestic purposes in the city.

The cultivated crops are few and the yield poor. It is, however, worthy of note that since the famine of 1851 the people have applied themselves considerably to agriculture, so that on the public lands of Fresnillo, which are four leagues square, there are now planted more than 450 fanegas (or about 720 bushels) of maize, which has rendered this district independent of Aguas Calientes, from which formerly all sorts of grain and forage were obtained, even for the country ranches, which latter are almost exclusively devoted to the rearing of cattle, sheep, etc. The character of the country is extremely favorable for this business, and it is carried on to so great an extent that on only nine of the largest ranches in this region there are over a million head of cattle and sheep.

#### METEOROLOGICAL OBSERVATIONS.

As soon as the meteorological instruments were received at the School of Practice, observations were begun upon the temperature, the atmospheric pressure, the humidity of the atmosphere, the direction of the winds, and latterly the amount of spontaneous evaporation. Of this series of observations, I have been able to obtain in this city (i. e. Mexico) only those pertaining to the months of October, November and December, 1855, and May, June, July, August, September, November and December, 1857. The monthly means of temperature and pressure for these months were as follows:

Month.	Year.	Temperature in Centigrade Degrees.	Barometric Column in Millimeters reduced to $0^{\circ}$ C.
October,	1855,	15.35	588.50
November,	"	15.68	586.15
December,	"	14.20	588.74
May,	1857,	23.47	586.52
June,	"	20.88	586.67
July,	"	21.68	586.83
August,	"	20.68	587.36
September,	"	18.22	587.81
November,	"	15.53	587.15
December,	"	13.21	587.09

General Mean of Temperature =  $17^{\circ}.89$  C.  
Barometric General Mean, reduced to  $0^{\circ}$  C. = 587.282.

For three months, in which the maximum and minimum temperatures of the day were observed, we have the following monthly means of maxima and minima.

Month.	Year.	Monthly mean Maximum.	Monthly mean Minimum.
October,	1855,	16.68	11.87
November,	"	17.51	7.20
December,	"	17.11	7.30

The barometric oscillations are of considerable magnitude and are powerfully influenced by the high winds which are very common in this climate, so that on the approach of a gale, the mercurial column falls suddenly and rapidly some six or eight hours beforehand.

The barometric altitude of Fresnillo above the sea, computed from the preceding data, is 2240 metres=7,349.22 feet.

The prevailing winds are south-westerly, and are often very high, carrying quantities of coarse sand with them. Less frequent are the north-east winds, which in the rainy season are a bad sign for the farmers, as they usually disperse the clouds. Northerly and south-easterly winds are the least frequent of all in the Fresnillo Valley.

The rain-fall, as already stated, is light, the yearly average being only from 30 to 40 centimeters, about 12 to 16 inches. Rains are most frequent from June to October; but there are occasionally in the months of January and March "aguas nieves," which consist of very light rains accompanied by a violent wind, and a temperature of  $10^{\circ}$  to  $12^{\circ}$  C.

From a long series of observations, it has been found that the average thickness of the sheet of water which will evaporate in the space of 24 hours in clear weather is 9 millimeters, about  $\frac{1}{3}$  inch.

#### GEOLOGY.

The rocks in this vicinity are chiefly metamorphic sedimentary, though igneous rocks also occur to some extent. The general direction of strike of the stratified rocks is about N.  $54^{\circ} 50'$  W., and the dip  $28^{\circ} 45'$  to the S. W. In the south-eastern portion of the mines, however, the strike changes and becomes from  $15^{\circ}$  to  $20^{\circ}$  nearer E. and W.

The *Cerro de Proaño* consists of a metamorphic Graywacke, which varies greatly in color, texture and composition. It generally contains iron pyrites disseminated through it in cubic crystals of various sizes, and also veinules and grains of calcite, as well as quartz, feldspar and other minerals. The approximate thickness of this formation is 1980 metres. It is conformably underlaid by the following series of rocks, viz :

1st.	290	metres of wavy clay slate.
2d.	310	" calcareous slate and shale.
3d.	1700	" metamorphic ("transition") limestone.
4th.	500	" thin alternating beds of clay slate, graywacke, and limestone.
	<hr/>	
	2890	
	1980	metres of overlying graywacke.
	<hr/>	
	4870	"

In the accompanying plot of the Fresnillo mines, the veins and the workings, so far as shown, are projected on to a horizontal plane at the level of the "Providencia" Drift. On this plot, the line of contact at the "Providencia" level between the graywacke and the underlying wavy slate, is indicated by a broken line.

No fossils have yet been found at Fresnillo. But from a careful comparison of the rocks of this region with those of other mining districts in Mexico, in one or two of which a few fossils have been found, I am inclined to refer the ore-bearing rocks of Fresnillo as well as those of Zacatecas, to the Devonian Age.

The whole surface of the lower parts of the great valley of Fresnillo is covered with sensibly horizontal beds of modern limestone ("*Caliche*"), marl ("*Barros*") and modern sandstone ("*Areniscas*"), whose geological age has not yet been proved, but which there is reason to believe are Triassic.

The igneous rocks in the region about Fresnillo consist of porphyries, trachytes and basalts. The different varieties of porphyry are very numerous, and it would involve much labor and little utility to describe them all. It will suffice to describe the two extreme varieties between which the others range.

The compact porphyry of San Albino is quartziferous, and has a compact jaspery groundmass of variegated colors. The crystals are of glassy feldspar very abundant, together with prisms and pyramids of transparent quartz of a vitreous luster. The general structure of the rock is conchoidal. It breaks into thin slices and also into trapezoidal fragments. It is tough and very hard. It is almost always porphyritic, sometimes banded, and the portions nearest the surface are scoriaceous. But it is never found decomposed, either as a whole, or in any of its ingredients. Its specific gravity is 2.53. It is so compact and hard that it is not used for building purposes. But it is very extensively used in the construction of arrastras, for which it furnishes the best quality of foundation and running stone to be found in the country. This porphyry forms extensive and tolerably smooth table lands, bounded at their edges by cliffs with perpendicular faces, in which the rock shows a strong tendency to columnar forms. The soil on these

table lands is thin and very sandy, and this fact combined with the cold winds which sweep over it and the early frosts which occur at these high altitudes, entirely unfit them for cultivation, though they are valuable as pastures for cattle.

The felsite, or "clay porphyry" of La Estanzuela, has a feldspathic ground-mass of reddish shades which is quite soft when first extracted from the quarry, but gradually hardens afterwards on exposure to the air. It is therefore easily and cheaply cut, and is used in ornamental building. It contains very perfect crystals of quartz, decomposed feldspar, and selenite; and there also occur in its mass large fragments of quartzose porphyry which have not experienced any decomposition whatever. The felsite adjoins, and to a certain extent is mixed with the trachyte, and it is sometimes very difficult to point out the respective limits of the two rocks. They may, however, always be distinguished from each other, inasmuch as the felsite does not contain pumice and pitchstone like the trachyte.

All the ornamental stone works in the buildings of Fresnillo are drawn from the quarries of La Estanzuela and La Grande, which are opened in the felsite and the trachyte. These quarries also furnish a fire-stone, which is used in the construction of furnaces, and is tolerably refractory.

The igneous rock which has produced the greatest disturbances and changes in the Fresnillo region is the quartzose porphyry, owing to its great volume and the extent of area which it occupies. The effects produced by it are—

- 1st. The upheaval of the Devonian Strata.
- 2d. The formation of the argentiferous veins of Fresnillo and Plateros.
- 3d. The general metamorphism which the Devonian Strata have undergone.
- 4th. The partial or complete alteration which certain rocks have suffered in immediate contact with the porphyry. For example, in Los Chilitos, El Pelon, and Valdecafias, where the graywacke has been changed into quartzite, and at San Demetrio and El Cerrito Blanco, where the compact limestone has been changed into granular limestone or marble. The absence of fossils in the Devonian rocks may also easily be due to the same cause.

The magnitude of these effects is so great that they cannot be attributed to either of the other igneous rocks, inasmuch as the appearance of the trachytes and basalts was subsequent to that of the porphyries, while their volume also is far less.

In addition to the great difficulties to be contended with everywhere in attempting to determine the epoch at which plutonic and volcanic rocks have burst through fossiliferous strata, we have in the region now in question the element of uncertainty in the determination of the age of the sedimentary rocks themselves, owing to the absolute lack of fossils. I will endeavor, however, to set forth the relations of the two classes of rocks to each other so far as possible.

The porphyry is of later origin than the sedimentary beds which I have considered as belonging to the Devonian Age, because it has uplifted them, forming a basin which has since been partly filled with more recent sedimentary rocks, dislocating and fracturing the Devonian strata, and thus giving origin to the

systems of veins of Fresnillo and Plateros. It has also produced permanent changes in the character of the sedimentary rocks as well as in the fragments of graywacke and slate which are enclosed in the porphyry itself.

But the porphyry is older than the beds of modern limestone ("Caliche") because in the conglomerate of the latter rock are found many rounded fragments of porphyry, and in some low places the "Caliche" has been observed to overlie the porphyry.

The trachytes and basalts are also both of them older than the "Caliche," forasmuch as the latter overlies them constantly and contains in its mass more or less fragments of them.

Thus it appears that the porphyry may have been ejected to the surface at about the beginning of the Carboniferous Age, and before the strata of that age were deposited. Such is the probable cause of the complete absence in this country of so important a formation.

The trachytes accompany the porphyries in the Sierra Fria, and in the mountains of Valdecañas, Valparaiso, Abrego, and the Picachos del Alamo. They occupy the highest parts of these ranges, overlying the porphyry, and are frequently mixed with the felsite. The most abundant variety of this rock exhibits rose red, brick red and grayish red, as well as greenish and yellowish gray colors, is not very hard, and contains crystals of glassy feldspar, and selenite, and fragments of porphyry, pumice and pitchstone. The presence of the two latter substances furnishes a decisive means of distinguishing between the trachytes and the felsites. The trachyte is more recent than the porphyry, for reasons already stated, but is older than the Basalt, as the latter has been observed at various points overlying the former, and in a basaltic conglomerate, or rather, tufa, fragments of trachyte occur.

The basaltic formation is of little importance in the Fresnillo Valley, as is evident from the few and small elevations which it forms and the little area which it covers. The basalt of Fresnillo is tough and compact, and breaks in sheets and trapezoidal fragments. It is of a grayish black color, and contains olivine, calcite, and magnetite. On its most elevated points it is scoriaceous, its cavities being partially filled with calcite. The elevations which it forms are low and rounded, with very gentle slopes. At those points where it comes in contact with sedimentary rocks, it has altered them powerfully; but the change does not extend to any great distance. The basalt is the most recent eruptive rock which is known at Fresnillo, as it overlies the porphyry and the trachyte. It is, however, older than the sedimentary strata to which the "Caliche" belongs, since in the mass of the latter there are found many fragments of basalt mixed with those of the other igneous rocks as well as of the older sedimentary rocks which form the under stratum of the valley.

PASCUAL ARENAS.

MEXICO, November, 1859.

*KEY TO THE SPANISH NAMES ON THE MAP OF SR. ARENAS.*

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Veta del Oro,.....	Gold Vein.
Veta de Santo Domingo, .....	San Domingo Vein.
Veta de la Barbosa,.....	Barbosa Vein.
Veta de Colorada, .....	Colorada Vein.
Veta echada de San Pedro, .....	Vein Echada de San Pedro.
Veta de Plateros,.....	Plateros Vein.
Veta de Jesus Maria, 6 de S. Cayetano,.....	Jesus Maria Vein, or San Cayetano Vein.
Veta de Santa Isabel,.....	Santa Isabel Vein.
Veta de Cueva Santa, .....	Cueva Santa Vein.
Ramales de Catillas,.....	Catillas Branches.
Ramales de S. Dionisio,.....	San Dionisio Branches.
Veta de Palomas, 6 transversal de Barreno,..	Palomas Vein, or Transverse Barreno Vein.
Veta de S. Carlos, 6 S. Silvestre, .....	San Carlos Vein, or San Silvestre Vein.
Sistema de la Veta Principal,.....	System of the Principal Vein.
Veta del Pilar,.....	Pillar Vein.
Veta de Candelaria, 6 de perros bravos, .....	Candelaria Vein, or Savage Dog Vein.
Ramales de S. Rafael y Mercedes,.....	Branches of San Rafael and Mercedes.
Veta de S. Ambrosio, .....	San Ambrosio Vein.
Veta de Agripo,.....	Agripo Vein.
Veta de las Lamas,.....	Las Lamas Vein.
Veta de S. Felipe, .....	San Felipe Vein.
Veta de S. Luis, .....	San Luis Vein.
Veta de S. Policarpio,.....	San Policarpio Vein.
Veta de Amarilla,.....	Amarilla Vein.
Veta transversal del Rosario, .....	Rosario transverse Vein.
Vetas del Rosario, .....	Rosario Veins.
V. de S. Ricardo, .....	San Ricardo Vein.
Veta de Santa Lugarda,.....	Santa Lugarda Vein.
Veta de Espiritu Santo, .....	Espiritu Santo Vein.
Veta echada del Tiro Nuevo, .....	Vein Echada del Tiro Nuevo.
Veta de la Novena,.....	La Novena Vein.
Veta de Providencia,.....	Providencia Vein.
Veta de S. Matias, .....	San Matias Vein.
Creston de la Veta echada de San Pedro, .....	Outcrop of the Vein Echada de San Pedro.
Veta de S. Angel,.....	San Angel Vein.
Ramales de Espiritu Santo,.....	Branches of Espiritu Santo.
Creston de la Veta de Espiritu Santo, .....	Outcrop of Espiritu Santo Vein.
Ramales de S. Nicolas,.....	Branches of San Nicolas.
Tiro general de Plateros,.....	General Shaft of Plateros.
Tiro de Santa Rita,.....	Santa Rita Shaft.
Tiro de Valdenegros,.....	Valdenegros Shaft.
Tiro de Sto. Domingo, .....	Santo Domingo Shaft.
Tiro de Salcidos,.....	Salcidos Shaft.
Tiro de Saraos, .....	Saraos Shaft.

Tiro de la Barbosa,	Barbosa Shaft.
Tiro de Ravago,	Ravago Shaft.
Tiro de Colorada,	Colorada Shaft.
Tiro de Dolores,	Dolores Shaft.
Tiro de S. Juan,	San Juan Shaft.
Tiro de la Diligencia,	Diligencia Shaft.
Tiro de S. Pedro,	San Pedro Shaft.
Tiro de Buen Suceso,	Buen Suceso Shaft.
Tiro de S. Nicolas,	San Nicolas Shaft.
Bartolina de Espiritu Santo,	Bartolina Shaft of Espiritu Santo.
Tiro de Espiritu Santo,	Espiritu Santo Shaft.
Cata de la Concordia,	Concordia Pit.
Tiro Nuevo,	New Shaft.
Cata del Rosario,	Rosario Pit.
Tiro de Amarilla,	Amarilla Shaft.
Cata de Encantada,	Encantada Pit.
Cata del Coro,	Coro Pit.
Tiro del Hepazole,	Hepazole Shaft.
Tiro de arrastre de Oscura,	Oscura Shaft.
Tiro de S. Vicente,	San Vicente Shaft.
Cata de Vivora,	Vivora Pit.
Tiro de Catillas,	Catillas Shaft.
Tiro de Barreno,	Barreno Shaft.
Tiro de Barrenito,	Barrenito Shaft.
Bartolina de Beleña,	Bartolina Shaft of Beleña.
Tiro g'ral de San Francisco,	General Shaft of San Francisco.
Tiro g'ral de Beleña,	General Shaft of Beleña
Crucero de S. Narciso,	San Narciso Cross-cut.
Crucero N. del Pilar,	North Cross-cut of El Pilar.
Crucero S. de Catillas,	South Cross-cut of Catillas.
Crucero de Amarilla, ó de la Compañía,	Amarilla or Company Cross-cut.
Crucero de Cueva Santa,	Cross-cut of Cueva Santa.
Crucero N. S. de Colorada,	Colorada North and South Cross-cut.

Sección transversal del Cerro de Proaño que pasa por el tiro de Buen Suceso segun una linea N. S.,-----	Transverse North and South Section of the Cerro de Proaño through the Buen Suceso Shaft.
Pizarra,	Slate.
Crucero de Alegría,	Alegria Cross-cut.
Crucero de S. Buenaventura,	San Buenaventura Cross-cut.
Crucero N. de Cueva Santa,	North Cueva Santa Cross-cut.
Piso de Providencia,	Providencia Level.
Crucero N. de S. Narciso,	North San Narciso Cross-cut.
Piso de Sta. Irene,	Santa Irene Level.
Piso de la Compañía,	The Company Level.
Crucero Sur de la Compañía,	South Company Cross-cut.
Piso 5°,	5th Level.
Salón del Diablo,	The Devil's Saloon.
Veta de las Guijas,	Las Guijas Vein.
Ramales, -----	Branches.

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Cuerpo alto de Amarilla,.....	Upper part of Amarilla.
Va. de Moctezuma,.....	Montezuma Vein.
Va. de Malinche,.....	Malinche Vein.
Va. Principal,.....	Principal Vein.
Vetas al bajo de la de S. Pedro,.....	Veins below that of San Pedro.
No. 1. Ramales de Guadalupe,.....	No. 1. Guadalupe Branches.
No. 2. S. Buenaventura,.....	No. 2. San Buenaventura.
No. 3. S. Quirino,.....	No. 3. San Quirino.
No. 4. La Cruz,.....	No. 4. La Cruz.
No. 5. S. Jorge,.....	No. 5. Saint George.
No. 6. El Almacen,.....	No. 6. El Almacen,
Serrania de Valdecañas,.....	Valdecañas Mountains.
Porfido Cuarcífero,.....	Quartzose Porphyry.
Basalto,.....	Basalt.
Cerrito de la Mesa,.....	Hill of La Mesa.
Vacia gris metamorfica,.....	Metamorphic Graywacke.
Caliche conglomerado y margas,.....	Limestone-conglomerate, and Marls.
Cerro de Proaño,.....	Hill of Proaño.
Cal Pizarra,.....	Calcareous Slate.
Mesa de San Alviro,.....	Table of San Alviro.
Porfido,.....	Porphyry.
Caliza,.....	Limestone.
Vacia,.....	Wacke.
Cº del Xoconostle,.....	Xoconostle Peak.
Cº de las Animas,.....	Peak of Las Animas.
Cº de la Leona,.....	Peak of La Leona.
<i>Sección transversal de Proaño segun el crucero</i>	
N. S. de Colorada,.....	<i>Transverse Section of Proaño through the North and South Cross-cut of Colorada.</i>
Crucero de Sº Domingo,.....	San Domingo Cross-cut.
Siliza Pizarra,.....	Siliceous Slate.
<i>Perfiles del Cerro de Proaño, tomados de O. a P., .....</i>	
	<i>Profiles of the Cerro de Proaño, taken from East to West.</i>
Piso del Horquillada,.....	Horquillada Level.
Piso de las Mercedes,.....	Las Mercedes Level.
Quinto Piso,.....	Fifth Level.
Sesto Piso,.....	Sixth Level.
Séptimo Piso,.....	Seventh Level.
Octavo Piso,.....	Eighth Level.
Noveno Piso,.....	Ninth Level.
Décimo Piso,.....	Tenth Level.
El Once,.....	Eleventh Level.
El Doce,.....	Twelfth Level.
El Trece,.....	Thirteenth Level.
El Catorce, .....	Fourteenth Level.
N. Magnetico,.....	North, Magnetic.

*NOTICE OF THE SILVER MINES OF FRESNILLO*

By AULD &amp; BUCHAN.

The Agents of the Government of Zacatecas, appointed with the approbation of Congress, to negotiate with parties who might be disposed to undertake the exploitation of the Fresnillo mines, are now able to add new details to their circular of the 15th of March of the current year.

The consideration of the unhappy results which mining enterprises in the Republic of Mexico have so generally yielded, would make us hesitate to offer any new incitement to English capitalists to venture into speculations of this kind, if the part which we have taken in said enterprises, and a residence of several years in that country had not convinced us that the losses and mistakes which have occurred are by no means due to causes necessarily inherent in whatever project may be formed to establish relations between English Capital and the mineral wealth of Mexico, and that none of the causes which have produced the greater portion of these sad results, exist in the case of the Fresnillo mines.

In the following statement, we shall endeavor to present an exact description of these mines, in the full confidence that it will be satisfactory to the public.

(Signed)

ROBERT O. AULD.

JOHN H. BUCHAN.

LONDON, No. 3 Haymarket, July 4th, 1834.

*MINES OF THE PRESIDIO.*

The Mexican Republic is modeled in many respects after that of the United States of America. It consists of a confederation of different States, each one of which is represented by its respective deputies in the General Congress of the Nation, but exercises within its own limits all the attributes of Sovereignty, having its own special Constitution, Governor and Congress.

The State of Zacatecas occupies an eminent rank among the other States of the Union, by reason of the liberal principles which characterize its Government<sup>(1)</sup>, its political importance, its mineral riches, and the solicitude with which

(1) By a law of the 23d of December, 1833, the Congress of Zacatecas concedes to foreigners the same rights and privileges which the citizens of the State themselves possess relative to the acquisition and possession of mines.

The advantages of this concession can be fully appreciated when we consider the fact that by the Mexican Mining Law, every citizen possesses the right of ownership to every mine which he may have discovered, whether it be a new one or an abandoned one, on the single condition that he makes the requisite declaration before a competent authority that his intention is to work it. He then continues to enjoy the whole product of the property so long as he continues to work it.

its Legislature fosters everything which can promote the public prosperity and the development of its natural resources.

The State of Zacatecas is situated between the parallels of  $21^{\circ}$  and  $25^{\circ}$  of North Latitude, and between the 100th and 104th meridians of Longitude West from Greenwich. Its area is about 27,000 square miles (English measure), and though it is under the tropic of Cancer, its situation upon the table land of Mexico, at an altitude of from 6,000 to 8,000 feet above the level of the sea, gives it a temperate and healthy climate, favorable to all kinds of work, and also to the agricultural productions of southern Europe. The population of the State according to the census of 1828, was 274,537. But in 1830, it had risen to 290,044, and in 1832, it was 314,121, showing an increase of 39,584, or one-seventh, in four years. In 1871, it was 397,945.

The revenues of the State amounted in the years 1827 and 1828, to \$1,525,821; in 1829 and '30, to \$1,688,098; and in 1831 and '32, to \$2,128,683, without including the product of the Fresnillo mines and some other resources.

The City of the Zacatecas, the Capital of the State, is one of the most important ones of the Republic. Including the Pueblos, which belong to the Municipality, it has a population of 34,000. Its distance from the Capital of the Republic is 380 miles, and it is connected with Tampico by a direct road 300 miles long.

In production of silver, Zacatecas has distinguished itself for many years among all the States of the Republic.

Of \$50,191,219, which were coined in the whole country in the five years from 1825 to 1829 inclusive, the State of Zacatecas alone contributed \$18,843,252, i. e. about two-fifths of the whole.

This rate of its production has been well sustained hitherto, its coinage in the three following years, 1830, 1831 and 1832, having amounted to \$14,363,211.

The mine which at the present time produces more silver than any other Mexican mine, and perhaps than any other in the World, is the Gallega mine, worked by the Bolafios Co. It is located in the suburbs of Zacatecas. In the last five years, from 1829 to 1833 inclusive, this mine has produced \$10,832,957; yielding a net profit of \$4,341,612.

The City of Fresnillo is situated about 14 leagues Northwest of the City of Zacatecas, in an extensive plain, which forms the greater portion of the State.

Its Latitude is  $23^{\circ} 9' 29''$  N., and its Longitude is  $102^{\circ} 46' 30''$  West from Greenwich. Its elevation above the sea is 7,284 feet, and its climate is temperate and healthy.

The Cerro de Proafio, in which the mines are situated, is an isolated hill rising out of the plain about a mile from the city. Its highest point is about 350 feet above the level of the plain, and its base is about 1300 yards long by 900 wide. The "Cerro" is a perfect net work of veins; and although it has not yet been explored to any notable depth below the base of the hill, there is good reason to believe that many of its veins extend to a considerable depth below the level of

the plain. And it is even true that some ramifications have been found which contained a little ore, in the digging of wells in the city itself.

These mines were discovered by the Spaniards shortly after the Conquest, and as they were productive even at the surface, chiefly in chloride of silver, they were anciently extensively worked, as is proven by the number and size of the dump piles which now cover the surface of the hill in every direction. In fact, there can be no other mines found in the Republic of Mexico which present such strong evidence of large production in the past. The "*Cerro*" is perforated in every direction, and almost its whole surface to-day is composed of what once formed its interior—a fact which increases in importance when we consider the slight depth to which the mining works have yet extended.

The upper portions of these mines being perfectly dry, the ore can be extracted from them with little work. But when we go below the general level of the plain, the difficulties caused by the infiltration of water commence, and they at last become so great as not to be overcome by the very imperfect means of unwatering which are used by the Creoles, so that all further progress in depth becomes impossible.

It would be a very difficult matter to name the various owners who have heretofore held possession of these mines. Suffice it to say that their working has been many times abandoned and resumed, and that their conformation is such as to produce a complete communication of the water between the various veins, so that whenever one owner attempted to unwater his own mine, he must at the same time unwater his neighbor's, thus giving them an advantage for which he paid the costs. This state of affairs has always been the cause of law-suits and troubles in the Republic of Mexico, and was the chief reason why the Fresnillo mines were entirely abandoned in 1757, after having been actively worked up to that time. The natural consequence was that after that time they were worked on a very small scale, and furnished subsistence only to a few individuals.

When English capitalists began to direct their attention to Mexican mines, this district was contracted for by the Mexican Company ("*Compañía Mejicana*"), but, for various causes which have never been understood, the company never attempted to work the mines, and after having had a law-suit with the owners, they at last abandoned the whole business, without having made the least attempt to work or explore the mines.

By a special decree of Congress in the latter part of the year 1830, these mines, at that time abandoned, and full of water,<sup>(\*)</sup> became the property of the State, and their boundaries at the same time were much enlarged. Active operations were commenced under the immediate supervision of the Government at the beginning of the year 1831. The whole product of that year was employed in preliminary buildings and repairs, and in attempts to unwater the mines and put

(\*) The population of Fresnillo, which had previously been large, did not at that time exceed 2000 people.

them in good condition down to the level of the deepest older works. The system of unwatering employed was that of malacates (or horse whims), which is the usual method of the country, and many of these machines were therefore built.

In the beginning of 1832, only twelve months after the commencement of operations, the amount of ore extracted was already considerable, and in March of that year the first product of silver was obtained.<sup>(\*)</sup>

In the rainy season, the quantity of water in the mines increased terribly—in fact to such an extent that it could only be controlled by immense efforts, requiring the continual work of from 28 to 30 malacates.

In the latter part of November, several new shafts had been sunk, other old ones had been sunk to greater depth, new veins had been opened in many places, and works were in progress for the discovery of others. The extraction of ore at the end of November amounted to 73,664 cargas,<sup>(\*)</sup> which produced \$757,866.

In consequence, however, of the political disturbances which had occurred a few months previously, the resources of the Government were necessarily employed in its own immediate defense, the amount of capital devoted to the mines was diminished, and the number of men called into service in the army having materially diminished the mining population, it was impossible to avoid the suspension of new works of exploration, and during a certain time only a part of the most productive portion of the mines was worked.

The year 1833 commenced under these unfavorable circumstances. But as political affairs began to put on a better aspect, and the war receded from the immediate vicinity of Zacatecas, a part of the miners returned to their work. The extraction of ore therefore gradually increased, and in the month of May, June, July and August, 1832, amounted to 3318 cargas of ore per week, containing over 9 marks of silver per monton.<sup>(\*)</sup>

In September, at the end of the rainy season, whose effects had for some time been so troublesome, the water had risen so much that it required 39 malacates to keep it in check. Besides this, the cholera appeared at Fresnillo, and during six weeks caused deathly devastation in the unhappy neighborhood, and almost completely stopped the unwatering of the mines. During this period the water rose considerably, and at last drove the miners out of the lowest and richest portions of the mines. In spite of all these difficulties, however, the yield from the last of

(\*) The short time required to repair these mines and put them in productive condition, is a very noticeable circumstance in their history, and is due not only to the activity with which the works were pushed, but also to their small depth, and the situation of the shafts and drifts in solid rock, where no timbering was required. One consequence of this was that when the mines were once freed of water they were generally found to be in very good condition.

(\*) The "carga" is 300 Mexican pounds, which is equal to 304.182 lbs. Av.

(\*) 3318 cargas per week, at 9 marks per "monton," amount to \$1,980,738 per year. The "mark" of Zacatecas = 7 oz., 7 pwt., 20.8 grains, English. The "monton" contains 20 quintals of 100 Mexican pounds each.

November, 1832, to the last of November, 1833, amounted to 144,772 cargas of ore which produced 193,470 marks and 3 ounces of silver—i. e. \$1,596,130—the expenses for the same time being estimated at \$1,447,130—thus yielding a profit of \$149,000.

In December, 1833, the unwatering was again begun on a smaller scale, and from the upper portions of the mines sufficient ore was extracted to pay the cost of working—i. e. about 2000 cargas per week. But the lower portions still remained under water. According to the latest advices from Zacatecas, the mines have again been unwatered so perfectly that the ore extracted from their lowest levels in the four weeks previous to the 22d of February, amounted to 13,700 cargas, equal in value to what was extracted in the months of May, June, July and August, 1833.

The experience of the year 1832 had already shown how difficult and costly it would be to continue the unwatering of the Fresnillo mines on a large scale by means of malacates.<sup>(1)</sup>

At the same epoch, the application of steam to the unwatering of the mines of "Real del Monte" and Bolafios<sup>(2)</sup>, furnished the Government of Zacatecas with sufficient evidence as to the power and economy of steam and the facility with which the necessary fuel can be obtained in this region, so that Don Francisco Garcia, convinced of the advantages to be expected from the introduction of steam engines, not only for the Fresnillo mines, but also for the general mining interests of the whole State, showed himself desirous of importing two high pressure engines from England, and gave authority for the raising of the necessary funds therefor in London by a loan or otherwise.

At the end of the last revolution, however, observing that the revenues of the State were too much reduced to enable it to continue the exploitation of the mines upon such a scale as their well-proved wealth and the interest of Zacatecas required, he determined with the approval of Congress at the end of the year 1833, to offer the Fresnillo mines to English capitalists upon very liberal conditions, in order to induce them to undertake and carry forward their working with the greatest activity and the most effective means.

The facts set forth in the preceding pages, together with the more detailed description which follows, will probably suffice to convince the reader that the mines of Fresnillo offer greater advantages for the employment of capital, with less risk than any others which have hitherto attracted the attention of English

(1) The cost of unwatering the mines that year amounted to \$300,300—three hundred men and 1500 animals being constantly employed at the malacates.

(2) If we compare the effect of the malacates on the Veta Grande with that of the steam engines at Bolafios in unwatering their respective mines in the year 1832, we find that by the combustion of 832 lbs. of wood the same quantity of water was raised as by the labor of 48 horses for 24 hours at the malacate, or that an effect equal to that of a whole day's work of a horse at the malacate was obtained by the consumption of 17 lbs. of wood—that is, by a less weight of fuel than the weight of the forage which the animal would require in the same time.

capitalists in the Mexican Republic. The Fresnillo mines do not present that uncertainty which always accompanies the re-opening of abandoned mines, and which arises from lack of information as to the condition in which they were left, or from the possibility that they may have been exhausted, or from the exaggerated estimates which may be formed of their richness. The Government has solved the question of their value by two years of uninterrupted and abundant productiveness.

The loss of time and the immense cost necessary to re-establish mines once ruined and abandoned, to repair the shafts and drifts already existing, or to sink and drive new ones, before reaching that part of the mines which is supposed to be productive (disadvantages with which most English companies in Mexico have had to contend)(<sup>9</sup>), do not present themselves in the Fresnillo mines. The Government has already cleaned them to the bottom, and they are to-day in working and productive condition.

There is one circumstance connected with the Fresnillo mines which can not fail to impress everybody familiar with practical mining, a circumstance upon which the principal hopes of the miner depend, and which directs and encourages his efforts—that is, the multitude of veins more or less metaliferous, and many of them very rich, which are encountered in a comparatively very limited space, thus presenting the greater facility for a general system of exploitation, and the felicitous application of steam in unwatering; advantages which perhaps no other mining property of equal extent has ever before offered. This property may without any exaggeration be considered, not as a single mine, but as an agglomeration of mines, and this fact gives it such great advantages over mines that are located only on a single vein, that if it is worked on a prudent and well devised system, dedicating always a certain sum to the driving forward of explorations on new veins, its product can never be subject to those great fluctuations(<sup>11</sup>) so common in the mines of Mexico, and so contrary to an economical exploitation.

The little depth of the present lowest levels in the Fresnillo mines,(<sup>12</sup>) compared with other mines of equal fame in Mexico, is another very noteworthy fact.

(<sup>9</sup>) It is more than seven years since the Bolaños Company commenced the reparation of the mines of that name, and such was their completely ruined condition that according to the annual report of the company, it had spent up to the end of the year 1833, \$2,499,845, without having yet reached the deepest portions of the mine, which were reputed to be the most productive.

In the Real del Monte, the English Company commenced its work by clearing up a tunnel more than a mile long and repairing a multitude of shafts (which had generally become filled up or were in a greatly ruined condition) down to a depth of more than 200 varas, before it could begin the unwatering of the lower parts of the mine by steam.

These preliminary operations occupied the company from 1824 to 1826; and it was only last year—i. e. nine years after taking possession of the mines—that the company succeeded at last in its chief object, which was to reach the bottom of the old workings.

(<sup>11</sup>) These fluctuations are called in Mexico, "Bonanza" and "Borrasca."

(<sup>12</sup>) The bottom levels of Fresnillo have not yet (1834) reached a depth of 40 fathoms, which is not the third part of the depth of Bolaños, Veta Grande and Real del Monte, nor the fifth part of Rayas, nor the eighth part of La Valenciana.

Their wealth would have been also exploited to the same depth as in other mines, but for the inadequacy of the machines employed to handle the quantity of water which filters into the mines from the extensive surrounding plains. This trouble would be overcome with the greater facility by the employment of steam engines, for the reason that the quantity of water is after all not very great, compared with that in other mines.<sup>(13)</sup> No other district of the Republic offers greater advantages for unwatering by steam, and its adoption would produce a saving of more than \$200,000 per year above the present system, furnishing at the same time the means of searching out the abundant ore to a depth and extent twice as great as what is now worked.

We have said that in spite of the very imperfect system of unwatering which has been followed up to the present time, and which during several months does not permit of working the deepest and richest parts of the mines—in spite of the reduction in the amount of capital employed which has permitted the opening of only a very limited portion of the district—in spite of the great hindrances arising from political disturbances and the disastrous visit of the cholera<sup>(14)</sup>, these mines produced, in the year 1833, \$1,596,130.<sup>(15)</sup>

The value of the mines of Fresnillo should not, however, be estimated by the product of a single year, extracted under so many disadvantages and with so imperfect a system of unwatering (though this would be an evident proof of their richness), but by what they will produce in the future, when the water shall be perfectly handled by steam engines, and the whole district can be actively exploited.

The months during which the Government secured the most favorable results were May, June, July and August, 1833, when the ore extracted from the limited portion of the District which was then working, amounted to 3318 cargas per week, containing 9 marks per monton, which is at the rate of 172,616 cargas of ore per year, worth \$1,980,738.

In the month of February of the present year, without the water having been

<sup>(13)</sup> The quantity of water of the Fresnillo mines may be estimated at 2,013,864 lbs., to be elevated one foot per minute, which does not exceed the quantity to-day extracted from Real del Monte and Bolaños, and is not the ninth part of that extracted from the mines of Cornwall.

<sup>(14)</sup> This fatal epidemic carried off in one month more than 2000 of the population of Fresnillo.

<sup>(15)</sup> The net profits out of this amount will perhaps seem very small in comparison with the gross product. But this is easily explained. Large sums were expended in the early part of the year of 1833 on dead works, among which was the draining of a neighboring lake whose waters were percolating into the mines, for which purpose a canal almost half a mile long was cut in the rock, passing at several places under ground. In June a fire destroyed all the malacates and buildings of the Barrenito mine, and it required \$25,000 to repair the damage. In addition to this, the resources of the Government not being sufficient to enable it to purchase the necessary materials and supplies at the most advantageous seasons, higher prices were paid for them than would have been otherwise necessary. And finally we must not forget that the cost of unwatering by animal power was \$300,300, while it could have been done by steam power for the fifth part of that sum. For all these causes, the smallness of the net profits in the past year is not to be wondered at.

extracted to a sufficient extent to permit of working the lower parts of the mines, the product exceeded that of the favorable months just mentioned.

If then, these mines have been able to produce such quantities, while it was possible for only a portion of the time to work their lowest levels; and if we suppose (which does not admit of a doubt) that the proper application of steam would enable it to be done at all seasons of the year, their annual product may, without passing the limits of a prudent appreciation of the facts, be valued at \$2,000,000. (10)

For the purpose of estimating the probable cost of working upon such a scale, the neighboring mines of Veta Grande worked by the Bolaños Co., furnish very clear and exact data. (11)

If then we estimate the costs at three-fifths of the gross product, as is the case at Veta Grande (and there can be no objection to this estimate) the net profits out of the \$2,000,000 will be \$800,000 per year. On the other hand the amount of capital requisite in order to assure this product would certainly not exceed \$750,000, so that the one-half of the product, that is, the part which would belong to the contracting parties, would be 32 per cent. of the anticipated capital, and the realization of this interest may be expected with confidence within two years from the commencement of the execution of the contract.

The foregoing exposition, which will be made yet clearer by the technical details and the explanatory notes which follow, and also by the plan of the mines hereto annexed, is submitted to the public in order to furnish convincing proof of the preference which the mines of Fresnillo deserve as a productive investment for capital, and especially as a very advantageous case for the employment of steam power in working them. \* \* \*

#### *EXPLANATORY NOTES.*

##### *ACTUAL CONDITION OF THE MINES.*

The Cerro de Proaño, in which are situated the mines of Fresnillo, is composed of transition graywacke, with some beds of clay-slate, a common formation in many of the metalliferous districts of Mexico.

(10) The extraction of ore, which serves as the basis for the aforesaid calculation, is that which was made from the veins actually worked by the Government, which are only a small part of those that appear to have been very extensively worked in the past in the Cerro de Proaño. As a general unwatering, exhausting the water from the whole district would give the greatest facility for exploring and working the veins which are now left idle, there are the best founded reasons for believing that the product of the district would much exceed the valuation expressed above.

(11) Veta Grande, which on the whole, one circumstance compensating for another, does not possess greater advantages than Fresnillo for economical exploitation of its mines, produced in the last five years, from 1829 to 1833 inclusive, the sum of \$10,832,927, the expenses being \$6,491,315, and consequently the net profits were two-fifths of the gross product—the mines having to support during that time an average annual expense of \$95,000 for the unwatering, and \$35,000 as war contributions, a class of tax from which the Government exempts the contractors for the Fresnillo mines, as well as from all increase of the duties on silver. (See the Report of the Bolaños Co.)

The ore of this district does not occur, as usually happens elsewhere, in a single mother vein, but in a multitude of small veins, of which more than fifty perfectly distinct ones have been discovered, with thicknesses ranging from one to six feet.

The direction of the principal veins is north-west and south-east, almost parallel with the line of greatest elevation of the Cerro, and their dip generally follows the slope of the hill; those in the north side of the hill dipping north, and those in the opposite side dipping south. This is the general aspect which they present. The exceptions can be seen in the plan, where the position of the color indicates the direction of dip of the veins, according as it is on one side or the other of the line which signalizes the veins.

The inclination of the principal veins at the surface forms with the horizon an angle of  $70^{\circ}$  to  $80^{\circ}$  and generally increases in proportion to the depth. The vein of San Pedro, however, has a greater inclination than the rest, being about  $55^{\circ}$  near the surface. It has been supposed that the veins which correspond to each other in direction and angle of dip on opposite sides of the hill are of contemporaneous origin.

The ores of Fresnillo are now of three classes, viz: "colorados," "negros" and "azulaques." The first class only occurs in the upper levels, and is not found at a greater depth than 70 or 80 varas. It consists of quartz, more or less ferruginous, which frequently passes into the condition of oxide of iron, and contains native silver, chloride of silver and sulphide of silver. It is evident that immediately beneath the surface, the chloride was very abundant, and in the early history of the mines formed the great mass of ore which was reduced by a peculiar method of hot amalgamation in copper vessels, called "*beneficio de cazo*."

The "colorados" are generally friable, and their appearance is such that without a long experience it is difficult to estimate their value closely by the eye, the silver being disseminated through the gangue in very minute particles.

The "negros" are found immediately beneath the "colorados," and were little known in this district previous to the last epoch of the resumption of work here. They form at the present time the greater part of the ore extracted, and seem to increase in value as the depth increases. This kind of ore generally consists of a compact ferruginous gangue, containing more or less silver, according as native silver or sulphide of silver is most abundant in it. It is easy to distinguish the "negros" from the "colorados" by their weight and metallic aspect. They are generally distinct from the gangue, but often mixed with quartz. In "La Oscura," the "negros" at a certain point contain a considerable quantity of copper pyrites, mixed with silver, which appears to owe its origin to a small vein of native copper which here intersects the principal vein. In the lower levels of "Beleña," pure sulphide of silver was found in a sort of white quartz gravel.

The third class of ore, which is almost peculiar to this district, and which is called "azulaques," is not found in the veins, but in the country rock, which is often impregnated on both sides of the vein for a distance of from one and a half

to two and a half feet with native silver, sulphide of silver and chloride of silver disseminated through it in very minute particles. It is more difficult to judge by the eye of the value of the "azulaques" than of the "colorados."

Some veins at the foot of the Cerro contain near the surface a small quantity of native gold, but in general the silver of Fresnillo does not contain gold enough to appreciably increase its value.

The sulphides of lead and zinc are also found in the veins as well as copper pyrites, and at one point native copper; but their quantity is not large.

The table of the quantity of ore extracted and worked in the year 1833, will show that the average product of the whole was 8 marks,  $7\frac{1}{2}$  ounces per montoñ of Zacatecas.<sup>(16)</sup> The "negros" may generally be considered as the best class of ore, and they averaged in the year 1833, about 4 ounces per quintal; the "colorados" about  $3\frac{1}{2}$  ounces; and the "azulaques" about 3 ounces. The quantity of smelting ore is small.

The veins situated in the north and east sides of the Cerro are the ones to which the attention of the Government has been chiefly directed, and the chief product up to the present time has been drawn from those of "Beleña," "Oscura," "Barreno," "Colorado," "Santo Domingo" and San Pedro. For the better arrangement of business they have been divided into four "administrations," or "districts," viz: "Beleña," "Barreno and Oscura," "Colorado," and "Plateros," which we will describe conformably with this division.

#### *DISTRICT OF BELEÑA.*

Six almost parallel veins running north-westerly, and all metalliferous have been discovered in this district. The chief one of these, which has been worked for 300 varas, has yielded tolerably good ore, and in a cross-cut from the San Francisco which had just reached this vein when the miners were driven out by water in consequence of the stoppage of the unwatering of the mines in August, 1833, first class ore was found. The extreme points of this vein so far as yet explored towards the east are also rich, which should be considered as a favorable fact, which promises that a good yield may yet be expected for some distance in that direction beneath the plain.

The other veins, where they are intersected by cross-cuts also show some ore; but they have hitherto been very imperfectly examined. The indications which they present, however, and the many parallel veins which are known towards the west (whose extensions will probably be intersected by the cross-cuts as these are driven further) are circumstances which justify good hopes whenever the exploitation of this district shall be extended.

The Beleña shaft situated at the south-east foot of the Cerro, is one of the principal points of unwatering. It is 83 varas deep, with a cross section 17 feet  $\times$  8. The Government enlarged it and sunk it to its present depth, and it

<sup>(16)</sup> 20 Quintals.

can now give employment to 8 malacates, 7 of which are already built. This shaft is surrounded by high walls, which enclose the malacates, and large office buildings, as well as stables and granaries for 400 animals employed in raising water at this mine.

Near Beleña, but outside of its district, is another shaft, that of San Francisco, of smaller dimensions ( $5\frac{1}{2}$  ft. square), but somewhat deeper than that of Beleña, where three malacates have been placed.

The Beleña shaft is perhaps one of the best situated for the employment of steam engines. The water seems to flow freely to this point, and can here be extracted from a less depth, and the carts of wood can unload at the very mouth of the mine. The numerous buildings which serve to-day as stables, coverings for the malacates, &c., can be utilized as sheds, workshops and lodging houses for the operatives employed about the engines and pumps.

#### *DISTRICT OF BARRENO AND OSCURA.*

The principal vein exploited in this District is that of "*Barreno y Oscura*," whose levels extend about 400 varas through ore of superior quality, the richest points being near the shafts of "*Barreno y Oscura*." Other veins have also been opened for nearly the same distance, all of which produce ore. In a cross-cut which runs 170 varas to the south from "*Catilas*," there have been cut as many as eleven separate veins; and in the whole district there have been discovered more than 35 distinct veins, some of which are parallel with that of "*Barreno y Oscura*," and some of which intersect it. They are all metalliferous, and show signs of having been productive near the surface, some distance beneath which they are being worked to-day—a fact which warrants the hope of finding much more, as the depth increases.

The veins, or in better words, the vein of "*Barreno*" and "*Oscura*" (for they are generally believed to be one and the same) is considered as the most important in this side of the Cerro. Its thickness in the deepest portions varies from  $1\frac{1}{2}$  to 5 feet. To the west of *Oscura*, its dip is towards the north, and it has not been worked beyond the shaft of *San Juan*. But the vein called "*Plateros*," which has been cut in the *Plateritos* shaft, is supposed to be identical with the former. To the east of *Oscura*, after having intersected a transverse vein, the mother lode changes its dip, and has not been explored beyond *Barrenito*.

In ascending the hill towards north-west from Beleña, the following shafts follow each other in order, viz: *Barrenito*, *Barreno*, *Catilas*, *Oscura*, *Buen-suceso*, and *San Juan*—the last being near the summit. At the three first, there are eleven malacates, and at the others there are seven, all working more or less in unwatering the mines. The respective depths of these shafts, and the elevation of their mouths above the level of the plain, will be seen by the profile which accompanies the plan. The buildings at these shafts are only roofs to protect the malacates from the storms, and ore patios which are not yet enclosed. But near

Barrenito extensive stables and granaries have been built for the animals employed in unwatering the district (whose number exceeds 600), as well as shops and offices.

#### *DISTRICT OF COLORADA.*

The most important veins of this District (situated on the northern side of the Cerro), are the three of Santo Domingo, Colorada, and San Pedro, which are almost parallel to each other. The first two produce excellent ore in considerable quantity. That of San Pedro, better known as the "*Echada de San Pedro*," on account of its flat dip ( $45^{\circ}$ ), is one of the most extensive in the Cerro, and near the summit it has been worked to a considerable depth beneath the surface. When it was first struck by the cross-cut which runs south from the Colorada shaft in 1832, the vein abounded in ore; but it was of so poor a quality that it did not pay the cost of extraction and reduction. In a lower cross-cut, however, the vein was found good enough to yield a profit, and good reason to hope that in greater depth its product will be very important.

In the veins of Colorada and Santo Domingo, the lowest levels have been driven 400 varas, and have yielded excellent ores; and their western faces, as well as the evident signs of extensive exploitations which have been carried on near the surface in that direction promise favorable results when the works are further extended towards the west.

In a drift to the south of the Colorada shaft, several unimportant veins have been discovered besides the ones which we have mentioned; but as they did not seem to be productive at the points where they were cut, little has been done in the way of exploring them.

The principal shafts are, Colorada, Ravago, Valdenegros and Santo Domingo. They have among them ten malacates. Santo Domingo and Ravago are occupied with the unwatering. The first is sunk in solid rock, and its section is  $8 \times 6\frac{1}{2}$  feet. It was intended for eight malacates: but at the present time it has only four working.

Another mine in this District, called "Barbosa," is the private proper of Don Teodoro Zapata, the present manager of the minds of Fresnillo. The Government gave him this position in consideration of his having abandoned certain claims which he had to the Oscura mine when the Government took possession of the District. His rights in the Barbosa, however, only extend to the depth of 113 varas below the mouth of the Barbosa shaft. The exploitation has already almost reached these limits, and below that the mine becomes the property of the Government.

The shafts of the Colorado District are not fenced around, but they have the necessary stables, and roofs for the malacates, as well and offices and shops.

*DISTRICT OF PLATEROS.\**

This District is situated towards the west, at the extreme foot of the slope of Proaño. Of all the different parts of the Cerro, this is the one which presents the least vestiges of surface workings. But those which do exist are sufficient to indicate the number of veins, and to inspire well founded hopes that this District when it shall be properly worked will prove as productive as the others. The Plateros shaft is entirely new, and the Government sunk it for the purpose of extracting the water. It is 76 varas deep, its mouth being 14 varas lower than that of Beleña, and its bottom being the lowest depth yet reached below the level of the plain. It has not yet cut any of the principal veins, and a drift of no great length is the only channel by which the water runs to this point.

Near the Plateros shaft, the little shaft of Plateritos is sunk on the vein of the same name. It has reached the depth of 60 varas from the surface, and in the bottom the vein already began to yield some ore. It was, however, followed no further, on account of the reduction of work at the beginning of the year 1833; so that the question of its future productiveness is not yet solved, although it is one of much interest.

The same necessity of reduction in the costs of exploitation prevented the driving of an intended cross-cut towards the south from Plateros, in order to explore the numerous veins which are seen on the surface in that direction, and which are supposed to be the continuations of the Santo Domingo, the Colorada, the San Pedro, &c.

The Plateros shaft is fenced about with high walls, and has in the same precinct, stables for 300 animals, and the roofs for eight malacates, six of which are already built.

On the south side of Proaño are situated the two mines of Rosario and Amarilla, whose exploitation was suspended in 1833, when the Government was under the necessity of limiting its operations, in spite of the favorable appearance which they presented, especially in a drift running north-west from Amarilla, which had already cut three ore-bearing veins. In Rosario, also, there have been four veins discovered whose appearance is among the best.

On the west side of the Cerro is the vein called "San Nicolas," which the Government acquired from the Ledesma family by a contract, according to the terms of which one-third of the net profit belongs to the proprietors, the Government having absolute control of the exploitation. In this vicinity a multitude of veins have been worked, and at some depth below the surface. In this mine there has been hitherto almost nothing done except to clean out the shafts and drive a level on one of the veins whose ore is of inferior quality.

The south-west side of the Cerro has been the least attended to since the resumption of work here. But that is no reason for supposing it to be inferior to the portions which have been worked with more energy. On the contrary, the

\* The Plateros District is not included in the property now (1883) held by the Fresnillo Company.

enormous piles of waste to be seen in this direction would lead us to infer that it had been formerly as productive as the other portions. An immense excavation near the summit is very notable on account of the number of veins which seem to have intersected each other at this point, and to have yielded a very large mass of ore. In order to explore this ground in depth, the Government began the "*tiro nuevo*" (new shaft). But when it had reached the depth of 75 varas, it became necessary to stop it on account of the same circumstances which compelled the suspension of many other explorations in 1833.

The plan of the mines shows only a small number of veins on the south side of the Cerro, it being impossible to describe them all, on account of the quantity of loose waste which completely covers this slope of the Cerro. In all probability, however, they are really just about as numerous here as on the northern side of the hill.

At the foot of the Cerro, below the Santo Domingo, are two parallel veins called "*El Oro*" (the gold), hitherto but little known, which near the surface have produced a little native gold.

In the plain, near the veins last mentioned, is the shaft of Salcidos, the object of which is to cut at a great depth the veins which on this side of the Cerro all dip towards the north, and also to serve as the principal shaft for the unwatering. As yet it has only been sunk 70 varas.

One very favorable circumstance for the Fresnillo mines is that the rock, though easy to excavate in every direction, whether vertical or horizontal, is sufficiently firm and solid so that timber is rarely needed to support the shafts and drifts, an advantage of great importance both in economy of exploitation and rapidity of working.

#### LIMITS.

The present limits of the Fresnillo mines are very extensive, forming a rectangle 4000 varas long from east to west, and 3000 varas wide from north to south. Within these limits, the only mine that does not belong to the Government, besides those of Barbosa and San Nicolas, which we have already mentioned, is a little one called "*La Valencia*," which also belongs to Don Teodoro Zapata. It is situated in the plain beyond Plateros, and at a sufficient distance to make its exploitation independent of that of Plateros or any other mine. It has been but little worked hitherto, and it has the privilege of not paying to the Government its contribution towards the general unwatering of the mines, which the mining laws require.

#### UNWATERING.

The unwatering of these mines has been hitherto accomplished by the Mexican method of malacates driven by animals. Four mules to each malacate work very rapidly, and raise to the surface the water which is in the bottom of the mines by means of a kind of leather buckets called "*botas*," which contain about

750 lbs. of water each. It is necessary to change the animals every two hours, and they work but once a day.

The effect of a single malacate is of small amount, as it can only raise 63,404. lbs. one foot per minute (a power much inferior to that of two horses). It requires for its daily service ten men and 48 animals, without counting any supplementary ones. The weekly cost of one of these machines, with forage at the ordinary price, is about \$165.—that is, \$8,580. per year, but rising as high as \$12,000. in bad years.

The quantity of water in the mines varies with the different seasons of the year, being greatest in the months of August, September and October—towards the end of the rainy season, whose greatest force is in June, July and August. In November, 1832, 35 malacates were required to keep the mines clear of water, and only 30 in the month of January following. In March they were reduced to 28. In August, when the cholera compelled a partial suspension of the unwatering, 39 malacates were barely sufficient to control the water; but in March, 1834, it was perfectly controlled by 32 malacates. The average number required for unwatering in the year 1833 may have been 30, which employed about 300 men and at least 1500 mules, and cost more than three hundred thousand dollars.<sup>(19)</sup>

Besides the great cost of the system of unwatering by malacates, its greatest inconvenience is that frequently these machines do not suffice to control a sudden increase in the quantity of water, which compels the abandonment of the best part of the exploitation. This happened in the rainy seasons of 1832 and 1833, during which it was hardly possible to work a week without interruption in the lowest levels of the mines. Nevertheless, the quantity of water is not so great that it could not be handled with ease by steam. There is abundant wood at a moderate distance from the mines, and the interval between the forest and the mines, is a plain over which ox carts are constantly traveling. The "carga" of wood, which weighs 300 lbs., and which in those mines of the Republic where steam has been applied, is considered as equal to a *fanega* (about 1.6 bushel) of charcoal, would cost at the mines about three-quarters of a dollar.

The conformation of the veins of the Cerro de Proaño, which cross each other in every direction, and permit the greater part of the water to run to the deepest shaft (an unfavorable circumstance for the system of malacates) affords great facility for the employment of steam engines, and for the execution of a well organized and effective general unwatering.

Another inconvenience of the present system of malacates is that on account of the large amount of space which they occupy, it has been necessary to place more or less of these machines at almost every shaft in the mines. And as the mouths of many of these are situated on the slopes of the Cerro at a considerable elevation

<sup>(19)</sup> Besides the animals occupied in unwatering, there are about 200 employed in the extraction of ore, and 500 in the reduction works, which swells the total number of animals belonging to the establishment to over 2000.

above the plain (as may be seen from the profile of the shafts) the water in many cases must be raised double the height which is necessary at the shafts in the plain. On the other hand, a steam engine located, for example, at Beleña, could concentrate at that point all the work of unwatering, while at the same time lifting the water to the least possible height.

The quantity of water drawn from the mines by 39 malacates in August, 1833, may be estimated at 2,472,756 lbs. raised one foot per minute. But the power which would have been required at Beleña with a steam engine would not have exceeded 2,013,864 lbs. raised one foot per minute—i. e. hardly four-fifths of the power actually employed.<sup>(\*)</sup>

It is calculated that two steam pumps with 60 inch cylinders and 10 feet stroke, the stroke of the pumps themselves being 8½ feet, would not only suffice to perfectly unwater the Fresnillo mines at their present depth, but also to enable work to be continued to the depth of 200 varas below the level of the plain, whatever increase in the quantity of water might occur.\*

The cost of these machines with their necessary accessories, their transportation to the mines, their foundations, and buildings, and the additional cost of setting them up and putting them in working condition, it is estimated would not exceed \$250,000. And it is computed that they would extract all the water now in the mines at a cost of \$50,000. per year. Of course the expense would increase as the depth of the mines and the quantity of water increased; but it is probable that at a depth of 200 varas it would not exceed \$70,000. per year.

The substitution of steam engines for malacates, then, would produce in addition to other advantages a direct saving of about \$250,000. per annum, or in other words a sum just about equal to their estimated total first cost.

But aside from the present cost of unwatering the Fresnillo mines the malacates now employed would not suffice for any much greater depth of the mines, and it would be impossible to increase the number of these machines as the increase in depth would quickly demand, without first spending large sums in sinking new shafts.

<sup>(\*)</sup> The steam engine employed in unwatering the Barreno mine of Bolaños, which has a cylinder 53 inches in diameter with 8 feet stroke of piston, and 6½ feet stroke of pump, lifts, according to the general average valuation for the year 1832, 1,812,989. lbs. of water, one foot per minute. It consumes 70.18 "cargas" = 21,054. lbs. of wood per day. The average effect obtained from one carga of wood during the whole year was, 37,199,510. lbs. raised one foot per minute; and the total expenses of the engine for the same length of time were \$31,252.

\* The two steam engines here named are now employed in the Hacienda to drive the stamps and arrastras; two much larger pumping engines replace them. See Report of Ortega & Son.—EDITOR.

## PRODUCTION IN THE YEARS 1832 AND 1833.

The extraction of ore was commenced at the beginning of 1832, and at the end of November of that year there had been extracted 72,664. cargas, of which 565. were smelted, 63. $\frac{1}{2}$  which contained chloride of silver, were worked by the "beneficio de caso," and 72,035. $\frac{1}{2}$  in the patio. The whole produced 621 bars of silver, containing 91,862. $\frac{1}{2}$  marks, worth..... \$757,866.

The average product of the whole quantity was 8 $\frac{1}{2}$  marks per "monton" of 20 quintals, equal to 3.4 ounces per quintal.

In 1833 the quantity of ore extracted amounted to 144,772. cargas, and produced 1,334. bars of silver, containing 193,470. marks, and worth ..... 1,596,131

The monton averaged 8 marks, 7 $\frac{1}{2}$  ounces.

Hence the total product from the beginning of 1832 up to the end of Nov., 1833, was.... \$2,353,997.

The two following tables will show the quantity of ore extracted in each month of the year 1833 from each of the four Districts, and also the amount of silver contained in each of the different classes into which the ore is divided in order to facilitate its reduction.

TABLE OF ORE DRAWN FROM THE DIFFERENT DISTRICTS OF FRESNILLO,  
FROM NOV. 30th, 1832, TO NOV. 30th, 1833.

MONTHS.	No. of Weeks in each month.	BELLERA.		BARRENO.		OSCURA.		COLORADA.		TOTAL.	
		Cargas.	Arrobas.	Cargas.	Arrobas.	Cargas.	Arrobas.	Cargas.	Arrobas.	Cargas.	Arrobas.
December, 1832,--	4	533.	0.	2,025.	0.	2,982.	5.	2,705.	0.	8,245.	5.
January, 1833,--	4	347.	6.	3,189.	0.	3,717.	6.	2,899.	0.	10,153.	0.
February, " "	4	123.	0.	2,585.	0.	3,420.	11.	3,646.	6.	9,775.	5.
March, " "	5	140.	4.	3,030.	0.	4,649.	9.	7,851.	6.	15,671.	7.
April, " "	4	308.	3.	1,929.	0.	2,895.	3.	4,025.	0.	9,157.	6.
May, " "	4	1,190.	10.	2,519.	6.	3,760.	5.	5,516.	0.	12,986.	9.
June, " "	5	2,125.	9.	2,925.	0.	5,314.	2.	7,414.	6.	18,779.	5.
July, " "	4	2,325.	7.	3,179.	0.	3,871.	4.	4,390.	0.	13,765.	11.
August, " "	5	3,949.	6.	2,692.	6.	2,824.	2.	4,726.	6.	14,192.	8.
September, " "	4	1,533.	11.	1,989.	6.	2,922.	10.	3,834.	6.	10,280.	9.
October, " "	4	1,498.	5.	2,441.	6.	2,864.	3.	3,277.	6.	10,081.	8.
November, " "	5	1,308.	2.	3,165.	6.	3,455.	8.	3,753.	0.	11,682.	4.
	52	16,384.	3.	31,670.	6.	42,678.	8.	54,036.	0.	144,772.	5.
Average product per week through the year,	Car-gas.	315.		609.		820.		1,039		2,784.	

Average product for the months of May, June, July and August = 3,318. cargas.

TABLE OF ORES EXTRACTED AND REDUCED IN THE YEAR 1833, SHOWING  
THE QUANTITY OF SILVER PRODUCED BY EACH CLASS OF  
ORE FROM EACH DISTRICT.

Name of District.	CLASS OF ORE.	Cargas.	Montons.	Silver contained in each Monton.		Total Marks.
				Marks.	Ounces.	
Beleña.	Smelting Ore, -----	479.	71. $\frac{1}{2}$	50.	4.8	3,617.
	Common Ore, -----	12,475. $\frac{1}{2}$	1,871. $\frac{1}{2}$	8.	0.	14,972.
	Ordinary Ore, -----	3,429. $\frac{1}{2}$	514. $\frac{1}{2}$	9.	4.	3,334.
	Total from Beleña, -----	16,384.	2,457. $\frac{1}{2}$	8.	6. $\frac{1}{2}$	21,923.
Barreno.	Smelting Ore, -----	187.	28.	50.	4.	1,414.
	Common Ore in hard pieces, -----	19,135.	2,870.	11.	4.	33,005.
	Common Ore, corn-grain size, -----	4,791. $\frac{1}{2}$	719.	9.	0.	6,471.
	Common Earthy Ore, -----	6,455.	988. $\frac{1}{2}$	8.	0.	7,748.
	Ordinary Ore, -----	1,102.	165.	6.	0.	990.
	Total from Barreno, -----	31,670. $\frac{1}{2}$	4,750. $\frac{1}{2}$	10.	3.	49,628.
Oscura.	1st Class, Common Ore, -----	7,143.	1,071. $\frac{1}{2}$	11.	0.	11,786. $\frac{1}{2}$
	2d Class, Common Ore, -----	35,535. $\frac{1}{2}$	5,330.	8.	0.	42,640.
	Total from Oscura, -----	42,678. $\frac{1}{2}$	6,401. $\frac{1}{2}$	8.	4.	54,426. $\frac{1}{2}$
Colorada.	Smelting Ore, -----	173.	26.	50.	4.8	1,315.
	Ore containing Chloride of Silver, -----	132. $\frac{1}{2}$	19. $\frac{1}{2}$	21.	0.	410.
	Common Ore in hard pieces, -----	31,496. $\frac{1}{2}$	4,724.	9.	2.	43,693.
	Earthy Common Ore, -----	19,423.	2,913. $\frac{1}{2}$	7.	0.	20,394. $\frac{1}{2}$
	Ordinary Earthy Ore, -----	2,814.	422. $\frac{1}{2}$	4.	0.	1,690.
	Total from Colorada, -----	54,039.	8,106.	8.	2. $\frac{1}{2}$	67,482. $\frac{1}{2}$
Total from all the Mines, -----		144,772.	27,715. $\frac{1}{2}$	8.	7. $\frac{1}{4}$	193,460.

#### REDUCTION WORKS.

For reducing the ores, the Government possesses two *haciendas* in the immediate vicinity of the City of Fresnillo. The largest one of these, called "*Guadalupe*," has three "*morteros*," and forty "*tahonas*," together with all the machinery and offices necessary for amalgamation, and four furnaces for smelting the richest ores.

The other *hacienda* is called "*El Rosario*." It has two "*morteros*," twelve "*tahonas*," and two furnaces. These works employ about 500 animals, and are capable of reducing 1300 cargas of ore per week.

There is also a private *hacienda* in the city, which does custom work, and can reduce 500 cargas per week.

These three *haciendas* are now the only ones in the vicinity of Fresnillo which are in working condition, though the ruins of many other old ones may be

seen. The ores which these three can not handle are sent to Zacatecas, and are worked principally in the *hacienda* of Bernardez, which belongs to the "United Mexican Company,"—in that of *La Granja*, which belongs to the Bolaños Co.—and in others which are the property of various private individuals.

The haciendas of Bernardez, *La Granja*, &c., are situated at the foot of the Zacatecas mountains, near the town of Guadalupe, and the road from there to Fresnillo, a distance of 14 leagues, lies in the plain. The ores are carried in ox carts, which are the commonest and cheapest means of transportation, the cost being from 6 to 7 reales (75 to 87½ cents) per carga.

#### *PRISON.*

The prison established by the Government at Fresnillo when it decided to reopen these mines, is a department entirely separate from the mining property. The prisoners, however, who number about 100, are chiefly employed about the mines. The discipline of the establishment is regulated by certain laws enacted for that purpose by the Congress of Zacatecas, which are strictly observed. The prisoners who work daily in the mines are escorted to them and back to the prison by a detachment of troops which the Government furnishes. For the work of the prisoners so employed, the mines pay to the prison, either the ordinary laborer's daily wages, or by the job, when the nature of the work permits it.

The presence of a body of operatives (almost all of them miners) who are under complete subjection and inured to the hardest work, is a considerable advantage in a country of scanty population, and where there is a natural tendency to idleness.

When work was resumed at these mines in 1831, the City of Fresnillo contained scarcely 2000 inhabitants, and, with the exception of the principal square, the houses were in the saddest state of ruin. But since then, houses have been built in every direction, and according to the census of 1832, the population has increased to 17,000.

The country for a certain distance around the city is level and fertile, yielding in the rainy season forage for the animals. A considerable area in the immediate vicinity of the mines has been irrigated by the water extracted from them, and when cultivated produces good crops of alfalfa for the mules which work in the mines. The whole plain appears to have been formerly cultivated, and in the last year good crops of maize have been raised in the vicinity of the city.

The position of Fresnillo upon the table land of the Cordilleras furnishes the best facilities for communication with all parts of the Republic. There is, it is true, no direct carriage road to the coast, the road to Tampico, 320 miles long, being only practicable for mules. But by going around to the north by way of Monterey in order to avoid the mountains (a circuit which does not double the distance), the road is perfectly suitable for carriages, and for the transportation of the heaviest machinery.

*M. DUPORT'S NOTICE OF FRESNILLO AND OF THE  
MODE OF TREATMENT OF THE ORES  
IN THE HACIENDA NUEVA*

FROM HIS "PRODUCTION OF THE PRECIOUS METALS IN MEXICO," PP. 254 ET SEQ.

The date when works began is quite uncertain, but the oldest titles date from 1755 to 1760. The exploitation of the Fresnillo mines carried on without much profit at the beginning of this century by certain miners who had grown rich at Sombrerete, did not assume any great activity till 1824, in which year it was resumed for account of the State of Zacatecas. After the establishment of the Central System, it passed into the hands of a company which shares the profits equally with the Government of the Republic.

*GEOLOGY.*

The Cerro de Proaño, situated 14 leagues N.N.W. of Zacatecas, is a hill 500 or 600 metres long, and not over 100 metres high above the surrounding plains, whose surface, covered by a deposit of recent limestone, is pierced at several localities by hills of porphyritic rocks of no great height. The uplifted mass of the Cerro de Proaño is a compact, yellowish, argillaceous rock, underlaid at a certain depth by a bluish argillaceous schist enclosing bands of white quartz.

*EXTRACTION.*

The whole surface of the hill is covered with the *débris* of former exploitations, and one travels over heaps of this yellowish rock (*wacke*) alongside of abandoned shafts and deep crevasses where the works were carried on as surface excavations. Since these important mines have passed into the hands of the present Company, the works have taken a more regular course, and are prosecuted by means of levels driven on the course of the veins, and 30 varas (25.44 m.) apart in depth. At the present time (1842) the 8th level is in progress, and judging from the time which has elapsed since the driving of the first ones, it appears that a new one is opened every seven or eight months. They are two metres in height and width, and their length varies from 800 to 1200 metres.

The Cerro is pierced by a great number of shafts which formerly served for the extraction of the ore, and the partial exhaustion of the water which by its abundance has necessitated the employment of steam. At the time of setting up the first steam engine, the mines being but little over 100 metres deep below the surface of the plain, the service was performed by 2000 horses. A second engine soon became necessary. Since its establishment the waters have not increased in

proportion with the depth. But nevertheless, in order to continue the work it will be necessary to furnish a third engine, or at least to increase the number of boilers and the diameter of the steam cylinders of the present ones, which will permit the lifting of the water from a greater depth by diminishing the diameters of the pumps. The pumps, placed in the vertical shafts, after reaching a certain depth, have been compelled to follow a slope parallel to the average dip of the veins; for the workings following the ore, departed farther and farther every day from the vertical line of the shafts, and as the water filtered only slowly through the rock, the workings were flooded while the bottoms of the shafts were dry. But by following the dip of the veins with the pumps this trouble has been obviated.\*

At Fresnillo, as elsewhere, the ores are divided into *colorados* and *negros*. The first are a very friable, yellowish mass, containing much hydrated oxide of iron, and but little metallic sulphurets. The silver which they contain is sometimes in the state of bromide, but oftener native. This alteration of the ores is not limited at this locality, as is generally the case, to a certain level; but at the same depths veins are found to be *colorados* or *negros* according as their composition has offered greater or less resistance to the decomposing action of external agencies. At Fresnillo are observed more frequently than elsewhere, masses, sometimes several metres in thickness, of very spongy hydrated oxide of iron having the appearance of bog iron ore, located where the change takes place from *colorados* to *negros*. The *negros* have a gangue of quartz, in which are enclosed blende, galena, and especially iron pyrites and arsenical compounds. Copper pyrites is much less abundant. The silver often occurs native, especially in threads; but it is principally in the condition of sulphurets simple or complex. Pyrargyrite, though often found, is much less abundant than at Zacatecas and Sombrerete, whose ores are the ones which have the most analogy with those of Fresnillo.

The costs of treatment having been greatly reduced within the last few years by great economies introduced into the administration, ores formerly rejected as too poor are treated to-day with advantage and form a considerable part of what is actually amalgamated. The costs due to the working of these rejected ores, are mixed with those of the present actual exploitation, and render it difficult to ascertain the true cost of the latter. But, taking a period during which this mixture was small in amount, we find that in six months, in 1839, the Proafio mines furnished 98,653 cargas of 300 Spanish pounds (138 kil.) of ore.

The costs of extraction amounted to .....	\$263,745.75
The costs of unwatering amounted to .....	76,274.62½
Making a total of .....	\$340,020.37½

Equivalent to \$3.43 per carga of 300 lbs. — \$22.87 for 2000 lbs.

\* The steam engines mentioned by Mr. Duport were replaced later by the more powerful ones now in action, and the others were set to do the mechanical work of the Hacienda.

The average yield during the same six months was 6 marks,  $\frac{3}{4}$  oz. per *monton* of 20 quintals; now, as 6 marks represent 0.0015 of the weight of the *monton*, if we increase this amount by one-third, we shall have 0.002 for the real contents of the ore, on the supposition that 25 per cent. of the silver is lost in the treatment.

If the *monton* of 2000 lbs. produced 6 marks,  $\frac{3}{4}$  oz. of silver, then the cargo of 300 lbs. produced  $7\frac{1}{16}$  oz., and assuming the value of the mark of pure silver to be \$9, we find that each mark of silver cost for extraction, \$3.75.

The cost of unwatering, amounting on the average to \$2,934, per week, while formerly with *malacates*, it was \$15,000 per week, we may conclude from this that when oak wood, cut one month previously, costs only 37½ cents per Spanish quintal, the cost of unwatering by steam is to that of unwatering with animals as 1:5 = \$7.50 per ton = \$13.12½ per cord.\*

#### METALLURGICAL TREATMENT.

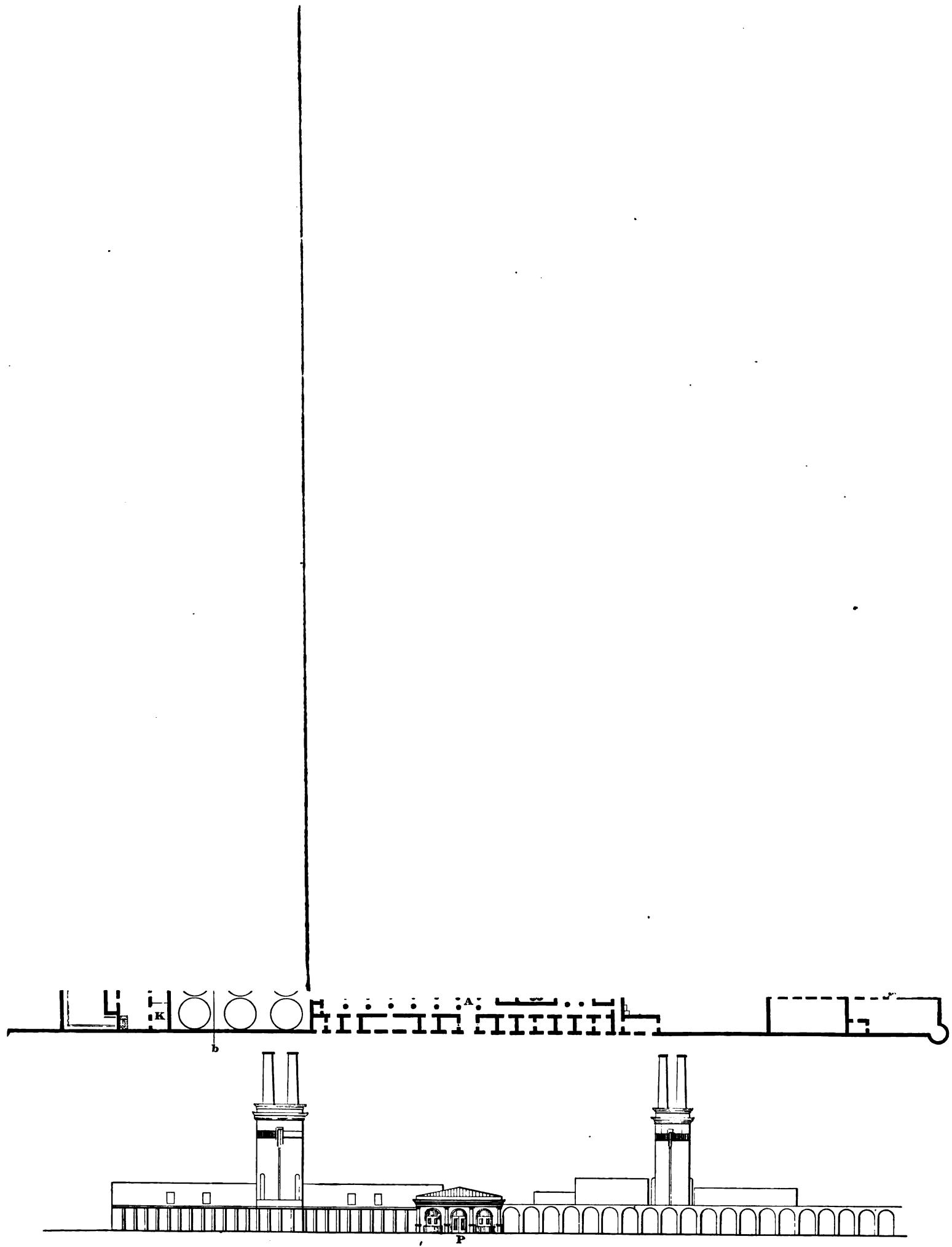
While the mines were being worked for account of the Government of the State of Zacatecas, but a small part of the Fresnillo ore was worked at that locality in two haciendas of moderate size, the greater part being transported to Zacatecas, where for a long time the number of metallurgical establishments has been in excess of what was required for the actual production of the mines. This division of the work, and the transportation of the ore a distance of 14 leagues, produced in addition to the extra expense, a multitude of inconveniences, among the most important of which were opportunities for theft.

When the Central Government of Mexico created the present Company, its management was confided to M. Anitua, a miner justly celebrated in the northern districts of the Republic, but whose practical knowledge and vast conceptions were unfortunately not accompanied by that strict economy which this sort of enterprise demands. Nevertheless, the advantages offered by the concentration of the metallurgical works at a single locality, did not escape him, and he energetically pushed the construction of the *Hacienda Nueva* of the Fresnillo Company, which is not only the most extensive, but also the best arranged metallurgical establishment that has ever existed in Mexico. These considerations have induced me to add to this work a plan of this vast *hacienda*, which has been furnished me with the consent of the Manager, by M. Doy, a French engineer, who has been for several years in the employ of the Fresnillo Company. (*For map see opposite*).

Situated in the plain, a few hundred metres from the Cerro de Proafio, this vast establishment is traversed by the water from the mines, which on leaving the pumps runs to the *hacienda* by its own gravity after having filled a reservoir which would feed the *hacienda* for several months, if for any unforeseen cause the work of the pumps should be suspended.

The *patio* occupies the centre of the establishment, and can hold at once 64

\* 1 cord dry average oak weighs 3500 lbs. ∴ 1 cord = 35 quintals ∴ 35 × 37.5 = \$13.12½. See article "Fuel," Johnson's Cyclopædia for a table of the value of wood.



*tortas* of 120,000 lbs. of ore each, which amounts to 7,680,000 Spanish pounds, or 3,582,000 kil. = 3,840 tons.

In the centre of this vast court is a fountain which furnishes water for the *tentaduras*. At each corner is a basin for washing the animals after treading the pulp. A covered conduit runs around the four sides of the square to carry water to the *lavaderos* and *arrastras*.

Three sides of the *patio* are devoted to *arrastras*, and there is room for 314 of them, though the work at the present time (1842) only occupies a little over 200. On the other side are rooms for casting ingots, with offices, and dwellings of some of the employés. The *lavaderos* are placed in the middle of each of the long lines of *arrastra* buildings. Each washing room contains two tubs, the stirrers of which are revolved by a whim on a floor above the tanks. Close alongside of the three *lavaderos* are the *azoguerias*, where the amalgam is filtered in order to produce *marquetas*,—and the *quemaderas*, covered with an open roof, under which are placed the bells (*capellinas*) employed for distilling the mercury.

Behind the *arrastra* buildings are the *molinos* (stamp mills) to the number of 12.

A second court which encloses all these buildings, contains other structures built against the outer walls, intended for magazines of all sorts and stables for 1500 mules or horses.

A third court, parallel to one of the sides of the establishment, is devoted to the *magistral* furnaces and the *planilla* washings.

The cost of this vast construction, which is not devoid of elegance, amounted to over \$300,000, a sum very quickly regained in the saving of transportation and the concentration of the metallurgical work at a single point.

The *beneficio* (working of the ores) at Fresnillo is far from yielding results like those at Guanajuato. More mercury is lost and a smaller percentage of the silver is extracted. This is due partly to the fact that the work is not so well conducted, but more especially to the nature of the ore.

At Fresnillo, as well as at Zacatecas, they say that very fine grinding does not produce a sufficient increase in the yield of silver to compensate for its additional cost; and therefore ten quintals (460 kil.) are passed through each *arrastra* in twenty-four hours, and the products, though finer than those of Zacatecas, yet seem very coarse to the touch. This less fine subdivision is partly due to the abundance of pyrites and other sulphurets which cleave into scales more readily than they break into fine grains like quartz.

After carrying the pulp to the *patio* it is not so long exposed to evaporation, but is worked so wet that the animals can tread it without trouble.

The salt employed is the *saltierra* of the *Peñon Blanco*. From 150 to 180 *fanegas*, or from 30,000 to 36,000 lbs. (13,800 to 16,560 kil.) of this salt are used for each *torta* of 120,000 lbs. (55,200 kil.).

Within the last few years considerable salt has been used from Colima, and especially from Alamo, a salt lake situated in the northern part of Mexico.

No use is made of sulphate of copper, the near neighborhood of Tepezala permitting *magistral* to be bought cheaply. From 5 to 40 lbs. (2.30 to 18.40 kil.) of *magistral* are used to 300 lbs. (138 kil.) of ore, according as the latter is more or less difficult to treat, and according to the season; for in winter the *azogueros* fear to employ too much of this material, on account of the great tendency which the *tortas* show to become "hot," (*calentarse*). This peculiarity which shows itself in the northern districts, and especially at Fresnillo during those months of the year when the thermometer falls below the freezing point—if not in the day time, at least for several hours in the night—seems explicable by the difference in solvent power exercised by concentrated solutions of salt upon chloride of silver, according to the temperature—phenomena which I have studied and of which I have given a detailed explanation in treating of the theory of amalgamation.

This modification of the solvent power of salt water according to the temperature being once admitted, we can understand that as the cold concentrates all the metallic salts in a part of the water contained in the *torta*, while the other part freezes, the chloridizing action of these salts, and particularly that of the dichloride of copper upon the mercury, should sensibly increase, while the chloride of silver, not dissolving so rapidly as it is formed, the amalgamation is naturally interrupted.

This almost complete suspension of amalgamation when the temperature falls to about the freezing point is also observed, though not so clearly, from 0° C. up to 10° C. The solvent action of the salt being greatly diminished by cold, we can easily understand that the cleaning of the surface of the molecules of silver by chemical action takes place more slowly, and must be supplemented by more frequent repetition of the mechanical action produced by the feet of men or animals in the *repasos*. Their number, therefore, is considerably increased in the same establishment and for the same ores during the winter.\*

The difficulty which exists in furnishing ore in sufficient quantities for the daily work of the *hacienda*, does not admit of separating the different sorts of ore, even into the two classes of *coloradas* and *negros*. And in order to keep the *molinos* and *arrastras*—which require a constant expense for the animals—always busy, it is preferred to mix indiscriminately all the products of the mines, which, nevertheless, consist of mineralogical combinations too widely different to be all of

\* The influence of mechanical action upon the duration of the work in the Mexican amalgamation appears to merit more attention than seems to have been given to it hitherto. An experiment made by Mr. Henry Mackintosh, Director of the Company of Guadalupe y Calvo, at the *Hacienda del Salto*, seems to prove how much the operation is accelerated by the mechanical cleaning of the surfaces. Two *tortas* of the same weight and the same mixture of ore were spread at the same time upon the *patio*. One of them, worked with eight *rapasos* of five or six hours each, at intervals of three or four days, required twenty-seven days. The other one, worked by causing the same number of mules employed in the *rapasos* of the first one to travel over it uninterruptedly day and night, was finished in eighty hours. The yield of silver and the loss of mercury in the two cases were sensibly the same. But the cost of the *rapasos* being very high at Guadalupe y Calvo, a double quantity of work for the mules in order to gain time was not profitable.

them advantageously subjected to one and the same treatment. When the *coloradas* and *negros* are worked separately it is observed that the former have a greater tendency to grow "hot;" but that nevertheless it takes them longer to become "*rendidos*," and that they occupy for equal weights a considerably greater volume than the *negros*. A *torta* of the latter mixed with salt from the *Peñon Blanco*, and with *magistral*, forms a circle about 18 *varas* (15.264 m.) in diameter and one-third of a *vara* (0.283 m.) deep. The *negros* require only from eighteen to thirty days of treatment. The *coloradas* sometimes requires as high as sixty.

The quantity of mercury employed up to the time when the *torta* is "*rendido*" is about six times the weight of the silver expected to be obtained. At the commencement of the operation two-thirds of this is added, and the other third is added later at two or three different times.

The number of *repasos* varies greatly according to the richness of the ore, from eight up to twenty, and sometimes twenty-five. Each *repaso* lasts five hours, and is performed by six horses.

When the *beneficio* is judged to be finished the *baño* is added. This consists of a quantity of mercury equal to four-fifths of what has already been used. The last *repaso* is then given, after which the ore goes to the washers. The washing is performed in a single tank of masonry, the bottom of which is one solid piece of porphyry, often four *varas* (3.39 m.) in diameter and one *vara* (0.848 m.) thick. The depth of the tank is two *varas* and three-quarters (2.33 m.). It is furnished with a double stirrer, the two parts of which are placed crosswise. Two of these tanks have their stirrers (or rakes) moved by a single whim worked by four mules placed on a floor above the tanks. Each tank washes two and one-half *montones*, or 5000 Spanish pounds per hour. This mode of washing is far inferior to the three consecutive tanks of Guanajuato, and the quantity of amalgam recovered from the *planillas* by a second washing proves how imperfect is the first one.

On account of the quantity of mercury added in the *baño*, the amalgam separated from the ore is very liquid, the ratio of mercury to silver being as 10 to 1. It is carried in this condition to the *azogueria*, where it is filtered through a bag of leather, the lower part of which is of hemp cloth, very strong, and very closely woven. These bags, called "*mangas*," hold from 2000 to 3000 lbs. of amalgam at a time. When the weather is very dry and several charges are filtered consecutively, there is a great disengagement of electricity, which being concentrated in the iron ring to which the leather of the *manga* is sewed, escapes in sparks whenever a man comes near it.

Each column of amalgam ready for distillation consists of 100 pieces (*marquetas*) of 20 lbs. each. It is covered with a bell of unrefined copper having an interior height of three English feet (0.912 m.), a diameter of one and one-half English feet (0.456 m.), and a thickness of one and one-half English inches. This bell, which weighs about 500 kil. is handled by means of a capstan, and its lower edge fits into a groove around the circumference of a stone basin, at the centre

of which the column of amalgam rests on an iron grating. Around the bell is built up a wall of refractory stone with openings in it. The intermediate space between the wall and the bell is filled with charcoal, and the firing is continued for 24 hours. The quantity of charcoal consumed is about 500 kilogrammes. During the whole time of firing a current of cold water passes through the basin under the iron grating and condenses the mercurial vapors which, resuming the liquid state, are collected in a special reservoir.

These 2000 lbs. (920 kil.) of amalgam yield 400 lbs. (184 kil.) of silver almost perfectly free from mercury. It is converted into ingots by melting in a reverberatory furnace, in the construction of which no precautions have been taken to avoid a volatilization of the silver, except to divide the chimney into three openings, one of which is placed facing the fire place, and the other two, one at each side. These three conduits unite in one above the dome which is hemispherical in form. The height of this dome and the diameter of the hearth are ordinarily one metre. 270 marks (59.80 kil.) are charged at once and melt in less than three-quarters of an hour, with 25 lbs. (11.50 kil.) of oak wood. When the fusion is complete the furnace is tapped, and the silver runs into two ingot moulds. With the powerful current of air required for so rapid a fusion, we should fear a considerable volatilization of silver. Nevertheless a quantity of 2700 marks, melted in my presence, showed a difference in weight before and after melting, of less than 5 marks, which in any case proves the perfection of the distillation of the mercury under the bell.

The ore pulps, after washing, are designated by the names of *jales* and are subjected to a supplementary washing on the *planilla*. The water carries off the quartz, the earthy particles and the blonde, while what is left of the amalgam is found on the upper part of the *planilla* with the galena and pyrites. This residue is called *marmaja*. It corresponds to about one fifth of the weight of the *jales* when the washing on the *planilla* is done with care. The richness in silver of these *marmajas* is then about 0.001, while that of the *jales* in front of the *planilla*, according to numerous assays which I made, is about 0.0003. This richness of 0.001, not being sufficient to pay the cost of smelting at Fresnillo, the washing is pushed still farther in order to get rid of what rocky particles still remain in the *marmajas* (about 0.15 of their weight), and a great part of the pyrites which is not very rich in silver, so as to greatly reduce the weight and obtain a new "schlich" in which the galena and the sulphurets of silver which have escaped amalgamation predominate still more. This new product is called "*polvillos*." It contains from 0.002 to 0.003 of silver, and leaves some margin above the cost of smelting. Of course this third washing is not accomplished without a great reduction of weight, so that the increase in richness in silver represents but a small part of that contained in the *marmajas*. In short, by concentrating the *jales* to such a point as to pay for smelting, more than four-fifths of their silver is lost, while a reasonable treatment of the *marmajas*, composed of mineralogical compounds upon which the *patio* treatment is without effect, would produce the

double result of being more economical than smelting and of saving the greater part of the silver of the *jales*, which by the present method is divided into two portions, of which the smaller, contained in the *polvillo*, leaves an insignificant margin above the cost of smelting, while the larger portion is, after the third washing, disseminated through such a mass of foreign matters that its beneficia-tion would not be thought of in any country in the world.

Unfortunately, whenever the question rises of employing any means not already known in Mexico, one finds among the miners insurmountable obstacles to the adoption of any change.

The Fresnillo Company is interested more than any other in modifying its system of treatment, so as either to obtain better results from the residue of the *patio*, or else, which would be better still, to treat its ores in the first place in such a way that these residues should not be so rich.

Although in many respects the administration of this vast enterprise is perfect, yet the almost indispensable assistance of docimastic assays has been contemned. An assay office originally established was afterwards suppressed on the pretext that its indications showed very irregular fluctuations, sometimes below and sometimes above the results of the treatment on a large scale. These differences, in all probability, did not come from the assays, but from mistakes in the weights of the *tortas*, considering how great is the difficulty in so immense a work of preventing portions of ore intended for one *torta* from being thrown into another. The need of assays, however, has been again felt and the assay office is re-established. But there is not yet organized an exact account and record of the assays of each quantity of ore worked, so as to render it possible by comparing the whole product for a year to compute with exactness the average difference between the assay and the yield. In 1839 this difference was estimated at 28. per cent. In 1841 and 1842 it was computed to be between 22. and 25. per cent. These last figures seem to be confirmed by the amount contained in the residues, if this be increased somewhat to allow for the extremely fine particles carried off by the water. In fact, as will appear later, the average yield for 1840, 1841 and nine months of 1842, being 0.0014, and the average contents of the residues 0.0003, it is seen that the latter figure is sensibly in the above ratio. (25 per cent. = 0.00035).

If it is difficult up to the present time to render an exact account of the value of the silver which escapes the metallurgical treatment,—this difficulty is no longer encountered so far as the quantity of mercury lost and the cost of the *beneficio* are concerned. The accuracy and intelligence with which all the accounts are kept, permit the rendering of an exact account of these matters for each month. The résumé of some of these documents which I have been able to collect, thanks to the kindness of the Director, M. José Gonzales y Echeverria, finds its place here.

*Résumé of the work of La Hacienda Nueva of the Fresnillo Company during the years 1840, 1841,  
and the first nine months of 1842.*

YEARS.	Montones of 2000 lbs.	Marks of Silver.	Value at \$8.75 per Mark.	Cost of Treatment.
		Marks. Oz.		
1840	31,955.	147,851. 3.	\$1,293,675.22 $\frac{1}{2}$	\$664,274.17
1841	35,291.	222,022. 0.	1,942,692.50	731,346.89
9 mo's 1842	28,324.	167,377. 3.	1,464,552.50	504,460.51
Total,	95,570.	537,250. 6.	4,700,920.12 $\frac{1}{2}$	1,900,081.57

These 95,570. montones = 87,924,400. kilogrammes of ore, which have produced 537,250. marks = 123,562.50 kilogrammes of silver; which gives an average yield of 0.0014 of the weight of the ore.

The cost of treatment per *monton* of 2000. lbs.; the average yield per *monton*, and the loss of mercury for each mark of silver obtained during the same period, were in the following proportions:—

YEARS.	Total cost of Treatment, including cost of Mercury.	Cost of Treatment exclusive of cost of Mercury.	Ounces of Mercury lost for each Mark of Silver.	Average yield per Monton.
			Marks. Oz.	Marks. Oz.
1840	\$20.78	\$14.43	14. $\frac{1}{8}$	4. 5.
1841	20.72	13.48	12. $\frac{3}{8}$	6. 2. $\frac{1}{4}$
9 mo's 1842	17.05	11.77	11. $\frac{1}{8}$	5. 7. $\frac{1}{4}$

We thus see that with ores yielding 0.0015 of silver, the loss of mercury at the price it costs in Mexico, amounts in value to about 30 per cent. of the total cost of treatment—a ratio which also holds good at Guanajuato.

The loss of mercury at Fresnillo has diminished within the last two years from 14 to 12 oz. per mark of silver obtained, and though this change is partly due to the increased care in the treatment, it is also partly due to the fact that the working of a certain vein charged with blende and galena and furnishing very rebellious ore for amalgamation, has been abandoned, or at least greatly diminished.

The following are some details of the cost of labor in the treatment:—Each *molino* requires in twenty-four hours:

2 *Arreadores* to drive the horses, ..... at 62 $\frac{1}{2}$  cents.  
6 Boys to feed the ore, ..... " 37 $\frac{1}{2}$  "

Six *arrastras* are cared for during the day by two men paid at the rate of 75 cents per *monton*. As all the work of charging and discharging the ore is done in the day time, ten men distributed through the whole establishment during the night are sufficient to keep the mules from stopping. These are paid 50 cents each. Six workmen do the necessary work for two *tortas*. The *arreador*, who drives the horses, gets 62 $\frac{1}{2}$  cents, and the five *repasadores*, who turn the pulp with shovels, get 50 cents each.

The ore is carried to the *lavadores* by the *cargadores*, who get  $3\frac{1}{4}$  cents per *monton*, and receive besides \$2. for cleaning out the bottom of a tank and washing the amalgam of a *torta*. Each tank requires the service of one *estiercolero*, whose business it is to plaster manure over the hand-barrows in order to prevent the pulp from sticking to them while carrying it to the *lavadores*. He gets 75 cents per day.

1 *Arreador* to drive the mules, for each tank, is paid..... 75. cents.  
2 *Lavadores*, or washers, for each tank, are paid..... 75. " each.

The smelting is performed by a master-smelter, who receives \$2 per day, and two laborers @ 50 cents each.

I transcribe here a statement of the work and detailed expenses of the Fresnillo *hacienda* for the year from Feb. 1, 1838, to Jan. 31, 1839. Its perusal will give a pretty accurate idea of the Mexican amalgamation practiced on a large scale. It will also be noticed that since that time, the administration being better managed, has reduced the costs considerably, since the *maquila* (i. e. the total cost of treatment, exclusive of the quicksilver), which was then \$15.20 per *monton*, only cost during the nine months of 1842 \$11.77, as already stated.\*

Statement of materials consumed at the Hacienda Nueva of Fresnillo, calculated at their cost price, from Feb. 1st, 1838, to Jan. 31st, 1839.

Forage,		\$ 75,281.42
Shoeing Horses and Mules,		1,659.00
Magistral, { 2,914. cargas at \$3.50,	10,199.00	}
" 8,525. " 5.75,	49,018.75	59,217.75
Salt, { Saltierra, 75,358. fanejas of 200. lbs. at \$1.37½,	103,617.25	
" Sal marin, 2,360 " 3.50,	7,670.00	111,287.25
Fuel, { Charcoal, 6,042. arrobas of 25. lbs. at 18¾ cts.,	1,132.87½	
" Wood, 90,685. " 6¼ "	5,067.81¼	6,800.69
Lime, 465. fanejas at 31¼ cts.,	145.31	
Blocks of Porphyry for grinding in arrastras,	3,907.75	
Almadinetas, or stamp-heads, and bronze for the amalgam retorting bells,	10,955.94	
Candles, for night work,	1,514.00	
Value of animals that died during the year,	484.00	
Various expenses for the shops,	4,503.93	
Table and Domestic expenses of the Administration,	7,576.62	
Laborers, by day's work, or task work,	79,732.55	
Employés at fixed salaries,	32,244.00	
Half the expenses of the Employés of the Administration, (N. B.—The other half is charged to the account of Extraction of Ore),	16,113.00	
Interest at 5 per cent. on 300,000., estimated value of stationery, apparatus and tools,	15,000.00	
Total costs, exclusive of Mercury,	\$426,423.21	
Value of 199,043. lbs. of Mercury consumed, at \$1.10 per Spanish lb.,	218,947.29	
28,047. montones, worked for a total cost of.....	\$645,370.50	

By comparing the quantities worked, the products, and the cost, as has been done for the years 1840, 1841 and the nine months of 1842, we have the following results:—

Montones of 2000 lbs.,	28,047.00
Marks of Silver,	229,035.00
Cost of treatment,	\$645,370.50

which gives an average yield of 0.002.

\* This cost has been reduced to about \$6 per ton on authority of Sr. Darqui in 1882.

Cost of treatment per <i>monton</i> , mercury included,.....	\$23.00
" " " exclusive of mercury,.....	15.20
Loss of mercury per mark of silver,.....	13. <sup>56</sup> oz.
Average yield per <i>monton</i> ,.....	8. marks, 1. <sup>14</sup> oz.

By reducing the 28,047. *montones* to pounds, we get for the total quantity worked 56,094,000. pounds, which cost \$645,370.50, and produced 229,035 marks of silver. From the detailed data of costs above given, we may therefore compute that a mark of silver cost \$2.818 for treatment, which cost should be distributed in different items as follows:

Items of Cost.	Dollars.	Percentage.
Cost of animals employed as motive power,.....	0.339	12.
Manual Labor,.....	0.349	13.
Skilled Work or Superintendence,.....	0.244	09.
Interest and Repairs,.....	0.131	04.
Fuel,.....	0.025	01.
Sundry small expenses,.....	0.027	01.
<i>Magistral</i> ,.....	0.260	09.
Salt,.....	0.486	17.
Mercury,.....	0.957	34.
Total,.....	2.818	100.

By this distribution of the costs of the Mexican amalgamation, we may easily see how well adapted is this system for a country where streams of water are rare and fuel very scarce.

Since numerous economies have been introduced into the vast enterprise of Fresnillo, the results have become more favorable to the stockholders.

It is not customary in Mexico to make a complete inventory of mining exploitations, in order to estimate the profit or loss within a given period, doubtless because the value to be placed upon the mine itself and the apparatus of exploitation is something very arbitrary. They generally proceed after a different fashion, which would not altogether satisfy European stockholders, but to which those of Mexico, who value dividends more than figures, are accustomed. The Director seeks to maintain the condition of his supplies and means always nearly uniform, and distributes among the stockholders all that part of the products not indispensable for working expenses. Thus at Fresnillo the distributions made for the two years 1841 and 1842 reached \$1,500,000,—always reserving about \$500,000 worth of materials of various kinds in the storehouses.

Whenever, by reason of diminution of production, the Director cannot meet the expenses, he calls for more capital, which the stockholders cannot refuse to furnish, under penalty of losing their title to the property, or at least their rights to subsequent dividends.

The great scale upon which these reduction works are carried on, renders it comparatively easy to observe its effects upon the animal economy, and leads me to add a few remarks upon that subject. In the first place, if the works of extraction exercise a deleterious influence upon the health of the workmen, who are almost

always exposed to great changes of temperature and obliged to breathe an atmosphere charged with mephitic vapors, and who often drink from mere carelessness or indifference waters holding in solution various metallic salts,—who are also exposed to perish by accident in perilous paths, where habit has often made them too heedless of danger;—the work of amalgamation, on the contrary, being carried on almost entirely in the open air, does not seem to affect the health of the great body of workmen employed, in spite of the constant presence of masses of mercury.

The *repasadores*, employed to turn over the pulp, and even to tread it with their naked feet in small operations, and the *lavadores*, charged with washing the amalgam, experience no inconvenience from these operations. The men who filter the amalgam and prepare it for distillation, experience quite frequently an irritation of the nervous system, which, however, is followed by no serious consequences. The *quemadores*, charged with the distillation itself, are the only workmen exposed to some danger, if a bell happens to crack, or the current of water is interrupted, when the mercurial vapors mingle with the air they breathe.

They then have all the symptoms of very severe salivation, from which they only recover slowly, and which ordinarily leaves them with a trembling from which they are never afterwards free. But it is very rare that these accidents happen, especially in the great *haciendas*, where the distilling apparatus is built and managed with the greatest care.

The horses or mules employed to tread the pulp are very fond of it on account of the salt which it contains, and they will often lick it, whatever precautions may be taken to prevent it. Sometimes this is the cause of their death, produced, undoubtedly, by the salts of copper, which also affect their legs, which are often covered with cracks. It is no uncommon thing to find a little ball of amalgam in the stomach of animals dying after long service in the *patio*.

*REPORT ON THE GENERAL CONDITION OF THE MINES OF  
THE PROAÑO COMPANY AT FRESNILLO ON JANUARY  
6, 1865, BY THE MINING SUPERINTENDENT  
OF THE SAID COMPANY.*

JOAQUIN M. RAMOS, MINING ENGINEER.

The general department of the mines is divided into three sections, viz., those of *Beleña*, *Barreno*, and *Plateritos*,—which we will consider separately, giving only a general idea of the condition in which their workings are, as well as of the works of reparation and improvement lately undertaken,—because a detailed report upon these mines would be laborious and would require time to prepare it.

*THE BELEÑA MINE*

Is divided into three sections,—the lower, middle and upper.

The lower section extends from the 5th to the 14th level. Most of its workings are in the San Pascual vein,<sup>(1)</sup> on the 10th general level. Its ores are black<sup>(2)</sup> and of good quality. This working, which is almost new, extends towards the west, where the vein is being explored also in the levels above and below, where it has hitherto been but little known. The extent of this working will therefore be greater in the future. For this purpose two workings are being pushed towards the west on this San Pascual vein, one of them on the 8th and the other on the 9th level, which are opening up a new *labor*. In this *labor* the elevation of temperature, due to the constant decomposition going on in the vein, is extreme, so that the fatigue of the workmen diminishes the amount of their work.

In order to facilitate the extraction of ore from here, the ventilation is being arranged for by way of the principal route towards the west, and for this purpose the work of putting into good condition the connecting *winzes* and the general levels from the 10th level upwards has been begun.

Besides the *labor* of San Pascual, the other *labores* noted in the tabular statement of the Distribution of the Workings, are also in progress. They are all in ores of good quality' "colorados" or "negros," on veins and ribbons above and below

(1) The average thickness of this vein is 0.75 metre.

(2) The predominant ores of these veins are "negros" (black) and "colorados" (red). The "negros" generally have a veinstone of quartz, carrying blue, black and white silver, blende and pyrites. The "colorados" usually contain quartz with white and green silver, and pyrites.

the principal vein. These veinules are innumerable, and therefore furnish some good *labores*.

At the present time two new *labores* of much promise are being systematically opened up, which will certainly contribute to increase the product of good paying ore. They are called "San Mariano" and "Las Lamas." The *labor* of "San Mariano" is in the principal vein on the 11th level, and was in good-pay ore. But by reason of the lack of most indispensable necessities, wood among the rest, during last year, up to the month of September, these workings were lost by the rise of the water up to the 10th level, and to-day, in order to regain it, the 11th level and the winze from the 10th are being cleaned out and repaired. As the vein was left in good pay ore, this will furnish another *labor* which will be opened up with good results, exploiting the vein of San Mariano itself, as well as its stringers and branches, which are called "Candelaria" and are also in good pay ore.

#### THE LABOR OF LAS LAMAS.

In the eastern part of this mine the Las Lamas vein has been worked out down to the 10th general level, and always yielded good pay ore abundantly. But the copious springs of water in Las Lamas have always rendered its working difficult, and as it continued in good ore down to the 10th level, in order to continue the exploitation of this rich vein, a work is being driven to connect the 10th and 11th levels, and thus unwater the 10th, when this *labor* of Las Lamas can be worked.

These important works of San Mariano and Las Lamas will be pushed as rapidly as possible in order to have two more good *labores* ready.

The *labores* on the 13th and 14th levels are not now working, as the cost of extracting the ore from them is, at the present time, too great.

Many of the veins which are well known in the upper levels still remain unexplored in the lower ones.

In the "Distribution of the Workings" of each mine are enumerated the good *labores* now working, the number of men employed in them, and the quality of their ores, described in the practical terms in use at this mining property.

*Distribution of the Workings of the Lower Section.*

Name of Labor.	Thickness of Vein.	Metres.	Character of Ore.	No. of Men.
Roof of Santo Tomas, on the 6th level, " Catillas, " 6th "	0.33 0.25		Tierras coloradas y boleo abronzado, Azogues negros abronzados,	8. 4.
Veinule in roof of Oscura, " 7th "	0.50		" michosos "	12.
Roof of Principal Vein, " 7th " " " 8th "	0.10 0.34		" negros " " guijos (gravelly) abronzados,	2. 4.
San Pascual, " 9th "	0.75		" negros guijos,	8.
Between 9th and 10th levels, San Pascual, Roof of San Pascual, on the 10th level, West Face of San Pascual, " 10th " Bottom of San Pascual, " 11th "	0.33 0.33 1.00 0.75		" " " " " " " " "	4. 6. 16. 16.

*MIDDLE SECTION.*

This extends from the 5th level up to the Providencia level (1st general level). Its ores are "colorados" and "negros" of good quality. The *labores* are situated on the veins above and below the principal one. The ones of most interest are those of San Martin, San Andres, San Mucio and El Pilar, which are new and solid. The *labores* of San Bartolo, Candelaria and La Purisima are intermediate between places already worked out and furnish for the most part the ores called "*Las Limpias*" (The Cleanings).

*Distribution of its Workings.*

Name of Labor.	Thickness of Vein.	Character of Ore.	No. of Men.
Roof of San Bartolo,	Metres. 0.25	Tierras coloradas,	16.
Floor of "	0.30	" abronzadas,	18.
San Andres, on San Yrene level,	0.24	Azogues abronzados,	18.
San Martin, " " "	0.33	Tierras coloradas,	8.
San Mucio, " " "	0.23	Azogues abronzados,	8.
" " San Narciso "	0.34	Tierras coloradas,	14.
El Pilar, " Providencia "	1.25	Azogues y tierras coloradas,	18.

*UPPER SECTION.*

This section extends from the Providencia level up to the *labor* of San Onofré, 80 metres from the surface. The greater part of it is worked out. Here is found the vein called "El Pozo del Agua," which is solid, with black and red ores of good quality. But its yield is small on account of the hardness of its walls. The *labores* of Catillas, San Leonardo, Palomas and Astillero are intermediate and the ore is obtained from a vast number of very variable branches.

*Distribution of the Workings.*

Name of Labor.	Thickness of Vein.	Character of Ore.	No. of Men.
Ribbon of Roof of Palomas, South of El Pozo del Agua,	Metres. Branches. 0.25	Azogues colorados abronzados, .	24.
East of Catillas,	Branches 0.24	" negros guijos,	10.
Roof of San Leonardo,	" 0.20	Tierras coloradas, " abronzadas,	8. 18.

*BARRENO MINE, Divided into two Sections, Colorada and Oscura.**COLORADA.*

The principal vein has been worked out in this mine as well as in the Oscura, down to the San Narciso level (second general level). The *labores* which are enumerated in the table of the "Distribution," are situated upon solid veins above and below the principal one. All the workings extend towards the west, which is little known and is new to exploration. In this mine there have lately been seven little veins of a good quality of ore, but not very thick, cut in the

North Cross-Cut of Cueva Santa. The length of this cross-cut is more than 300 metres, and the *labor*, which it was attempted to open on the little veins which were cut, was stopped by bad air. The miners could not work there, and furthermore, the extraction of the little ore that was obtained was very costly. In order to render these *labores* accessible and continue the explorations of the cross-cut further to the north, a shaft called *El Porvenir* is being sunk, which at the depth of 100 metres will cut the latest discovered vein called *La Bien Venida*, whose ores are *colorados* of fine quality. This shaft has also the advantage of being situated at a favorable point to facilitate the extraction of the ores from the greater part of the *Colorada* workings.

*Distribution of the Workings.*

Name of Labor.	Thickness of Vein.	Character of Ores.	No. of Men.
Floor of San Cleopas,	Metres.	Negros abronzados,	24.
" San Estéban,	Branches.	" "	8.
" La Can.pana,	En cuartones.	Tierras "	16.
" San Buenaventura,	Metres 0.60	Tierras coloradas y boleo abronzado,	8.
Ramales de Remedios,	0.10	Calichones negros,	18.
Roof of Santo Domingo,	0.04	En guija con pinta negra,	6.
" Cueva Santa,	0.05	Negros michosos abronzados,	4.
" San José,	0.05	" " "	8.
Floor of Santo Domingo,	0.25	" " "	4.
" San Felipe,	0.17	" " "	4.

*OSCURA.*

The *labores* of Jesus Maria, San Andres, Santa Escolástica, San Claudio and Purisima, which are situated relative to the principal vein like those of *Colorada*, are solid and in good paying black and red ores. The *labores* of La Alegria, Santa Rosa, Mercedes and San Narciso are intermediate, and correspond in general to the ancient workings and to the great "caves" which furnish "*Las Limpias*" of this section.

*Distribution of the Workings of Oscura.*

Name of Labor.	Thickness of Vein.	Character of Ores.	No. of Men.
Floor of San Claudio,	Metres.	Ramaleos negros abronzados,	16.
" San Narciso,	0.05	" " "	12.
Eastern Santa Rosa,	0.10	Tierras carresealores,	6.
Western "	0.04	Negros abronzados,	8.
Eastern San Ygnacio,	0.05	Colorados "	6.
Roof of Mercedes,	0.06	" "	12.
Western "	0.08	Negros "	10.
Roof of La Purisima,	0.11	Michosos "	6.
Western San Escolástico,	0.09	Tierras coloradas y bronces,	16.
" San Andres,	0.04	Negros abronzados,	10.
Floor of Jesus Maria,	0.07	" "	8.

The principal vein was worked out in these mines, as already stated, down to the 2d general level, where the character of its ores changed, and they became rebellious to treatment by the *Patio* process. The exploration of this vein in depth and toward the west was therefore abandoned in order to exploit the others which furnish to-day the greatest part of the workings. In the Beleña Mine, the principal vein was exploited in good ores toward the west as far as the Oscura shaft, and down to the 8th general level. But in greater depth, and always farther east, the ore has been rebellious, wherefore this working is also abandoned.

#### *PLATERITOS.*

This new mine, the most westerly of the Department, has a body of the principal vein which has formed the *labor* called "La Trinidad de San Miguel." The depth of this *labor* does not exceed 90 metres, and its extension towards the east is not over 200 metres. This direction is most explored and most promising, because here are found the best paying ores of the vein--"colorados" and "negros"--such as have not hitherto been found farther towards the west.

The vein of Jesus Maria, which is situated below the principal vein, is regular in its formation, and a new *labor* is being opened up upon it, which is following the course of the vein itself towards the east.

The *labores* of "Los Locos," "Santa Eduviges" and "La Alcancia," are on veins above and below the principal one. They all of them follow towards the east the direction of the Cerro de Proaño, into which they enter.

If the workings are extended on towards the east as they are going now, they will connect with the old Plateritos shaft and improve the condition of the mine by supplying ventilation and better facilities for the extraction of material.

*Distribution of the Workings.*

Name of Labor.	Thickness of Vein.	Character of Ores.	No. of Men.
	Metres.		
Roof of La Trinidad,	0.25	Tierras coloradas y abronzadas,	10.
Roof and Floor of San Miguel,	0.75 to 1. m.	Azogues negros y colorados,	30.
Floor of La Alcancia;	0.15 @ 0.25	Azogues colorados y tierras,	6.
" Jesus Maria,	0.50	Guijoso abronzado y negro,	4.

#### *Fortification, (i. e., Strengthening and Supporting the Works.)*

In all the mines and especially in that of Beleña, which is of most interest in this respect, attention is given to the *labores* in order to preserve them and also for the safety of the miners. In the mines of Colorado and Plateritos, whose walls are solid, the consumption of wood for timbering is of little account. But the case is different in the Beleña mine, in which places are found where the workings can not advance on account of the softness of the walls of the veins. To-day the attempt is being made to replace timber by walls of stone, which are of course better, but can not be used in all places for the reason above indicated.

*Works of Reparation and Improvement which have been Executed, and which are now  
Actually in Progress.*

*REPARATION.*

In the Beleña shaft a number of sets of timbers, both in the inclined and vertical portions. Other sets yet remain to be repaired.

In the San Francisco shaft, the work of stopping a breaking, or crushing, which extends from the level of San Narciso up to that of San Onofré (80 metres from the surface.)

This crushing, which threatened to ruin the shaft, resulted from its being surrounded at this locality by the great excavations occasioned by the working out of the rich veins of San Policarpio, Las Hijuelas, El Trenzado, &c., whose yield was very abundant and whose walls were so soft as to allow great chambers to cave in, the effects of which were afterwards felt even on the surface. At the same level of San Narciso there is also placed one of the counterpoises of the machinery, which, after the shaft had begun to yield, contributed to increase the trouble which had been in progress for the three previous years. But within that time the mining superintendent has only been allowed to make partial and very frequent repairs—perhaps from fear of the great cost of complete repairing—and the evil has not been abated, but has gone on increasing. In order, however, to remedy it once and for all, the necessary points are now being strengthened with stone walls which will secure the shaft.

In the shaft of Buen Suceso, a great stretch of 30 veras which was crushed in by the caving of the "Catillas" chamber, has been repaired and timbered, and the beams of the *malacates* have been renewed.

*WORKS OF IMPROVEMENT.*

The following, all of which are important, are being executed by job work in the three mines. They were carefully reconnoitered before undertaking them, and their object in general is to open new *labores* and improve their conditions. They are distributed as follows:

*In the Beleña Mine.*

The Western Front of San Pascual, on the 8th level, To open a new *labor*.

" " " 9th " " "

Winze in Las Lamas " 10th " A drain to facilitate the opening and working of a new *labor* in Las Lamas.

*In the Barreno Mine.*

Eastern part of Santo Domingo, To explore this vein and open a new *labor*.

North Cross-cut of Cueva Santa, To explore the ground farther north in "Colorada."

Eastern Front of San Cleopas, To open a new *labor*.

A Winze in " " " "

Western Front of Santa Genoveva, " " "

Shaft of El Porvenir, To ventilate and connect with the new *labores* in the northern part of Colorada and to cut, at the depth of 100 metres, the vein of La Bien Venida. This shaft is already 40 meters deep, 10 of which are timbered and the timbering is still going on. A malacate is also building for the service of the shaft.

*In the Plateritos Mine.*

Eastern Front of La Trinidad, Opening a labor and driving the 1st level.  
 " " San Miguel, " " " 2d "  
 " " La Esperanza, " " " 3d "  
 " " Jesus Maria, " " and driving a level below the principal  
 vein.

Though it is impossible to execute all the needed repairs at once, yet what is absolutely necessary for the safety and preservation of the mines should be promptly done.

In this report, I have been able to give only a sketch of such matters as are of the first importance, by reason of the haste and urgency with which the resident Directors required it, in order to forward it to the *Junta Directiva* (Board of Managers) in Mexico, to enable them to take such measures as the present situation of affairs demands.

A detailed report would be laborious and would require time to prepare it. For this reason I have here set forth only the general condition of the workings, with such facts as I believe to be of greatest importance at the present time.

[Signed] JOAQUIN M. RAMOS.

PROAÑO MINING CO., FRESNILLO, JAN. 6TH, 1865.

ZACATECAS, MONDAY, JULY 31ST, 1882.

I hereby certify that the foregoing Report is a faithful copy of the original, which I left in the office of the Proaño Mining Company on the 6th of January, 1865, which Report was made by me in my own handwriting, as Mining Superintendent of the Proaño Company, which position I held at the time of making said Report.

In witness whereof, I hereunto affix my signature.

JOAQUIN M. RAMOS.

{  
SEAL.  
}

U. S. CONSULATE,

ZACATECAS, 1ST AUGUST, 1882.

I, the undersigned, Vice Consul of the United States of America for this City and the Dependencies thereof, do hereby certify that the foregoing is the true and genuine signature of Joaquin M. Ramos, formerly Head Miner of the Proaño Negotiation, and as such is entitled to full faith and credit.

Given under my hand and the seal of this Consulate the day and year above written.

A. M. KIMBALL.

{  
SEAL.  
}

UNITED STATES CONSULATE GENERAL,  
CITY OF MEXICO, SEPTEMBER 13TH, 1882.

I, David H. Strother, Consul General of the United States of America at Mexico City, hereby certify that the name of A. M. Kimball, subscribed to the foregoing Certificate, is the true and genuine signature of the United States Vice Consul at Zacatecas, well known to me, and that the seal thereto affixed is the proper and recognized seal of his office, and worthy of full faith and credit.

In testimony whereof, I have hereunto set my hand and seal on the day and year next above written.

DAVID H. STROTHER.  
*United States Consul General.*



*REPORT OF MANUEL ORTEGA & SON, ASSIGNEES  
OF THE MINING COMPANY OF FRESNILLO.*

TO THE GENERAL MEETING OF SHAREHOLDERS ON THE STATE IN WHICH AT PRESENT  
ARE THE MINES OF PROAÑO AND THEIR ACTUAL PROFITS. 1881.

The city of Fresnillo is situated about 40 miles N. W. from Zacatecas, in an extensive plain which forms the greater part of the State, in  $23^{\circ} 9' 29''$  of Northern latitude, and  $102^{\circ} 46' 30''$  of Western longitude; its elevation above the level of the sea is 7,284 feet, and its climate is temperate and healthy.

The hills of Proaño, in which the mines are situated, rise from the plain towards the S. W. at about a mile from the city. Their summit rises 350 feet from the level of the plain, and their base is 1,300 yards long, by 900 broad.

These hills are completely intersected by veins to a considerable depth below their base, and many of these veins extend far below under the plain.

The Cerro de Proaño is known to contain, according to scientific investigations, *bacia gris* (Graywacke) with alternating layers of slate and clay. The silver is not found, as it is generally in other mines, in one particular vein of ore, but is distributed over a number of different veins, more than fifty of which may be counted perfectly distinct and whose dimensions vary from one to six feet.

The direction of the principal veins is from N. W. to S. E., almost in a parallel line with the highest parts of the hills. Their dip generally follows the slope of the hills; that is to say, those on the north side descend towards the North and on the other side they dip Southwards. There are other transverse veins, which are usually very productive.

The ores are of three kinds: black, red and bluish. The first are found in the upper levels, and are not met with at a greater depth than 70 or 80 yards. They are composed of more or less ferruginous quartz, which frequently passes into oxide of iron, and contains native silver, chloride of silver (*plata verde*) and sulphide of silver. Just below the surface it is seen that the chloride has been abundant, and at the time when the mine was first worked it formed the greater part of the ore, from which it was extracted by a peculiar mode of amalgamation in heated copper vessels. This was called "*Beneficio de cazo*."

The red ore is generally friable and its appearance is such that, without great experience, it is difficult to ascertain at sight its real value, because the silver is distributed in the ore in very small particles. The black ore is found immediately below the red, and it appears that its value increases according to the depth at which it is found. This kind of ore is composed of compact iron ore, mixed with silver, of which it gives more or less in proportion to the virgin silver, or sulphide of silver which it may contain, and which can be extracted from it. It is easily distinguished from the red ore by its weight, and its metallic appearance and is usually found associated with quartz.

The third kind, which is peculiar to this district, and which is called *azulaques*, is not found in the veins but in the adjacent rocks, which are frequently impregnated to a great distance on both sides of the principal vein with virgin silver and sulphide and chloride of silver, disseminated in minute particles.

Some veins at the foot of the hills contain on their surface a small quantity of virgin gold.

In some veins there is found yellow copper ore and veins of sulphuret of lead and zinc, and in one spot there is virgin copper, but not in any great quantity.

The limits and appurtenances of Proaño are very extensive and form a rectangle of 4,000 yards from East to West and of 3,000 from North to South.

The vicinity of Fresnillo for a certain distance round the city is level and fertile, affording an ample supply of forage for animals, and there are easy means of communication with all parts of the Republic.

The establishment of Proaño is divided into two departments: that of the mines, which is situated, as has been before stated, in the Cerro of Proaño, and the *Hacienda Grande*, where the ore is worked and amalgamated.

The mines existing in the Cerro are: *Belenia* and *San Francisco*, two principal ones; *Barreno*, *Oscura*, *Amarilla*, *Colorada* and *San Pedro*, *Buen Suceso*, *Barrenito*, *Valdenegros*, *La Diligencia*, *Catillas*, *San Vicente*, *Espíritu Santo*, *San Nicolds*, *Plateros*, *Plateritos*, *Santa Rita*, *Tecolotes*, *Tiro Nuevo*, *Santa Efigenia*, *El Pópulo*, *Saraos*, *Cata de Neblina*, *el Rosario*, *Rdbago*, *Santo Domingo*, *El Oro*, *San Aparicio*, and seven others: besides there are several open cuts or mines of little depth, some of which, from the aspect of the surface, give good expectations.

The condition and number of these mines is as follows:

The principal one, *Belenia*, with a depth of 400 yards; *San Francisco*, also a main shaft, with a depth of 515 yards, reaches to the lowest level, and is in perfect condition. That of *Oscura* reaches the tenth level, and is estimated at 410 yards. According to the latest reports its shoreing had fallen in in the upper levels. That of *Buen Suceso* reaches the sixth level and measures 305 yards; its shoreing has fallen in in the upper part to a depth of 40 yards. *Barreno*, fallen in, measures 150 yards. *Colorada* in good condition, reaches to the general level of *La Compañía*, and measures 250 yards. *Amarilla*, in good condition, reaches the same level and measures the same depth as the former.

*Valdenegros*, in good condition, has been sounded to a depth of 150 yards; it is not known how far it may have been worked. *San Pedro*, in good condition; its depth is unknown. *Catillas*, sunk in; *Espíritu Santo*, in good condition for a depth of 60 yards, when it is found to be closed. *San Nicolds*, in good condition for 65 yards, when it is found to be closed; its extent is unknown. *Plateros*, in good condition; its depth is not known, but is calculated at 100 yards.

*Plateritos*, in good condition; the same extent as the former. *Santa Rita*, in good condition: is closed up at 50 yards. *Tecolotes*, in good condition; its extent not actually known. *Tiro Nuevo*, in good condition; its depth not known. *El Pópulo*, in good condition; measures 50 yards. *Saraos*, *Rdbago* and *Santo Domingo*

communicate with *Colorada* at 160 yards; the subsequent distance made is not known. *El Rosario*, in good condition; has been explored for 70 yards; its extent is not known. *El Oro*; this shaft is new and only reaches 25 yards. *El Porvenir*, in good condition; is calculated at 80 yards. *La Concordia*, in good condition; its depth not known. *Dolores*, in good condition for 50 yards, where it is blocked. *Barrenito*, in good condition; measures 70 yards. *El Corito*, in good condition for 60 yards, where it is blocked. *San Juan*, in good condition; is calculated at 150 yards.

The mines are divided into five departments or administrations, in the following order: the first and principal is *Belén*.

In the principal enclosure there are situated at the main shafts of *Belén* and *San Francisco*, two high-pressure steam engines for pumping out the water, the cylinders of which measure eighty English inches in diameter, with nine feet stroke. The pump bore (*bombero*) of *Belén* measures eighteen English inches in diameter, that of *San Francisco* fifteen inches.

As has been formerly stated, the main shaft of the first mine is 400 yards in depth and reaches to the twelfth level. The pumps reach to the same depth. This shaft is vertical as far as the fifth general level, from which an inclined portion starting from the *Providencia* level, leads to the lower levels. The machinery is complete in all its parts, and is at present working. The machinery of *San Francisco* is also working daily, and supplies all the water required for the *Hacienda*. The shaft of this mine is also vertical and reaches to the lowest level, the fifteenth, from which the steam pump raises the water.

The mines of *Belén* and *San Francisco* have become united, from their workings having met. These extend to a very great distance, mostly from East to West in the hills, and there is a distance of about 30 yards between each level. The first level in *San Francisco* is *San Onofre*, with extensive workings which give abundance of good ore.

The second is the general level of *Providencia*, and contains extensive workings, in which have been found rich ores, worthy of notice, especially in those of *Santo Cristo*, of *San Pascual* and *Agripa*, *Candelaria*, *Platosa* and others; this level, as has been before stated, forms part of the principal levels cut through various veins of other mines, and is prolonged to a considerable distance from E. to W. The third level is the general level of *San Narciso*, in the same condition as the former. The fourth is the level of *Santa Irene*, with the workings in the same condition.

The fifth is the general level of *La Compañía*. The sixth is the fifth general level, and the others follow in the same order to the fifteenth and last. It must be stated that from the twelfth to the fifteenth levels the workings are of limited extent, so that it may be expected that great profits will be derived from the rich ores known to exist in these levels. From the sixth to the tenth levels there runs a vein called "*Las Lamas*," in which the ore is found in clayish soil, which has given very rich returns.

In the shaft of *Belen* the first level is *el del Horquillado*, with abundant reserves of profitable ore. The second is the general level of *Providencia*; the others follow in the same order to the twelfth. At this point, by means of a cross-cut, *San Francisco* supplies this shaft with water, which proves that the water in the works is pumped out by the sole power of the two engines which are at work.

The storehouses of the mines are situated in this same department; large, lofty rooms, very well roofed with strong timber, dwelling houses for engineers and clerks, stables, etc. In these stores there is a great quantity of tools for the use of the machinery, and duplicate pieces for replacing in case of accident; a large turning lathe, which is completely new, and a steam whim, also new, for both machines, brought out from England, have not yet been put together. The iron foundry is in the same department with two large thick plated furnaces, capacity 6,000 lbs., and two for melting copper, which contain 2,000 lbs. The driving wheel is of wood, worked by the same water which the steam pumps raise. It measures twenty-two feet in diameter. There are a great number of patterns for replacing the pieces of the machinery which may be worn out or destroyed. Communicating with the foundry and put in motion by the same wheel, there is an iron turning lathe, in very good condition, but of smaller dimensions than the one before mentioned. There are also in the same storehouses, the principal pieces of a steam engine, the cylinder of which is sixty inches in diameter, so that with very little extra expense there would be another machine for pumping or other work besides the steam whim already referred to. There is also a powerful machine for cutting cold iron, and different kinds of machinery for various uses, all of which are of great service to the Company.

It must be mentioned that the machinery of *Belen* and *San Francisco* is located in elegant and solid brick buildings, strengthened all round by thick iron plates, and the boilers are protected in the same way.

In the center of the principal court-yard there is a large tank of stone and masonry which serves as a reservoir of water for the iron foundry, and outside there is another larger reservoir, used at times to contain the superfluous water which may be needed for different purposes.

The water in the mines is found at 35 yards from the shaft head of *San Francisco*, for which reason the first level of the mine, which is at the depth of 65 yards, is not yet opened.

When the works of the present company and the machinery of *San Francisco* was put in motion in December, 1878, water was found at 30 yards in this shaft, which proves that the machinery now in existence suffices to prevent the rise of the water, which has considerably diminished. It has been noticed on different occasions when iron castings of considerable weight were going on, and for this reason the machinery worked more than usual, the water fell in the parts of the mines that are actually being explored. It has been already stated that the machinery of *San Francisco* is put in motion for the sole purpose of providing water for the use of the Hacienda; it stops every night. It may be fairly

deduced from these facts, that the pumping of the mines can be accomplished by the two steam engines already mentioned, and with still greater facility if, to their power, which is calculated to reach to the lowest level, there were added other pumps which would give more channels for carrying out the water.

The second department of the mines is *Barreno* and *Oscura*, which form one; it is situated on the N. W. side of the hill, and its principal vein has been one of the richest and most productive. In a cross-cut from this mine, towards the South, there are eleven separate veins. In this district there have been found more than thirty-five distinct veins, all of them metalliferous, and of the richest description. Some of the principal workings are the *San Ambrosio*, *el Quelele*, *San Rafael*, *Tabor*, *Mercedes*, *Remedios*, *Veta de Plateros*, *La Concordia*, *Jesus Maria*, and others.

The third department is *Amarillo*, situated on the South side of the hill; this mine is one of the richest, and is probably the one which really gives most promise for the future, because its workings are new, and its levels are not yet thoroughly explored. Its principal workings are *San Jose*, front, floor and roof; *Guadalupe*, the same, front, back, and shaft of *Martires*, *San Blas*, *el Triste*, *San Miguel*, and others, there having been extracted from the ore of these mines as much as a "barra de plata" from a "monton de tierra" of 2,000 lbs. The fourth department is *Plateros*, situated at the western extremity of the hill. This department is the one which has been the least explored, but many of its veins have produced a very good class of ores. It appears that at the time when the "Zacatecano-Mexicana" company existed, the director thought of opening another general shaft on the principal vein, with the object of cutting across the various veins that run westwards, the richness of which has been proved on the opposite side.

The department of *Colorada*, situated on the north side of the hills, has at different times attracted attention by the abundance of its returns and the richness of the ores. In certain workings there have been found very rich smelting ores. As illustrative of the extensive developments which this department contains, we may mention some of the principal ones, viz: *Cielo de Remedios*, *La Campana*, *San Esteban*, *San Cleopas*, *San Antonio*, *San Macario*, *San Luis*, *Las Nieves*, *San Buenaventura*, *Echada de San Pedro*, *Cielo de la Calor*, *Frente Oriente*, *Crucero Sur*. The *San Pedro* was worked for its full width at the surface as an open cut (*a tajo abierto*).

We have already alluded briefly to the extensive buildings which belong to the department of *Belenia*; in the others already referred to there existed at one time ample accommodation for the managers and head workmen, as also stables, barns, yards (surrounded by high walls), which were used for the sorting of the ores. The buildings of *Plateros* are standing, and the roofs in good condition; the buildings of *Barreno*, *Colorada* and *Amarilla*, are unroofed; as also those of the mine of *San Nicols*, which belongs to *Plateros*.

The upper parts of these mines are perfectly dry, and the ore is extracted with very little trouble by means of whims. The several departments possess six of these, which are worked by horses; four small whims, which are capable of

extracting the ore from a depth of two or three hundred yards, and two others of greater power which are placed in front of the steam engines for general use in the shaft, as well as for raising the ore from the lowest levels. A noteworthy circumstance in these mines, and which is greatly in their favor is, that the rock, although easily excavated in all directions, either vertical or horizontal, is so firm and solid that it is seldom necessary to timber the shafts and levels, which is a great advantage, as well for the economy of the workings as for the rapidity with which they can be carried on.

Messrs. Manuel Ortega & Son state further that everything is in good order at Proaño, including the pumping engines and machinery. All that is wanting is the capital necessary to purchase fuel to keep the pumps in constant motion. The greatest depth of water is stated at 390 yards (Spanish) about 1072 feet. It is also stated, as the result of experiment, that the cost of pumping is one thousand dollars each yard of depth, or say \$390,000 estimated cost for completely unwatering the lowest levels. But at the moderate depth of 80 yards are found the abundant and rich ores on the *Providencia* level, which it is believed are alone sufficient to maintain the works. At present the only mines worked are those of *Neblina* and *El Rosario*. Profitable ore is extracted from both these, and in a cross-cut which reaches the *Amarilla* yet richer ore is obtained. Three hundred *montones* (tons) of ore are extracted each week at present from these mines, which fully cover the cost of the workings and improvements.

The crushing machinery and arrastras in the Great Hacienda are now driven by two steam engines with cylinders measuring sixty inches (English) in diameter and with nine feet stroke, capable of treating 140 tons of ore in twenty-four hours, consuming daily 200,000 lbs. of oak wood (= about 5 to 6 cords) costing about \$65. These engines are placed in well-constructed brick buildings near the assay offices and melting furnaces, and replace with an economy of probably 75 per cent. the cost of animal power formerly employed to do the same work.

*REPORT UPON THE PRESENT HEIGHT OF THE WATER IN  
THE BELEÑA MINE, THE LABORES WHICH ARE  
FLOODED, AND THOSE WORKING ABOVE  
THE WATER LEVEL.*

The water stands 13.75 varas above the 6th level in the San Francisco shaft. This shaft, which is the deepest of all, extends 10 varas below the 14th level. The levels are driven 30 varas apart, measured on the dip of the vein. The *labores* flooded by water are

*1. Las Lamas, on the 10th Level.*

This *labor* is far advanced to the east of the Beleña shaft, and the water is very abundant, so that it cannot be worked until the water is drained from the 11th level. Its vein, one vara thick, in the form of a pocket which comes down from the 7th level, abounds in black ores of excellent quality.

*2. Laborio de Agripo.*

This *laborio* is on the 14th level of the San Francisco shaft. Its vein, two varas thick, is in strips of black and other ores with very solid walls. On the 12th and 13th levels there has been some work done on this same vein, but the condition in which it was left is of no great interest. Though the faces of the drifts on this vein are not very far advanced towards the west, that of the 12th, which advanced beyond the principal, discovered good and abundant pay ore, but with extremely soft walls and much water.

*3. Plan de San Pascual,*

Between the 10th and 11th levels to the west of the Oscura shaft. Its extent from the east to west is 200 varas, more or less. Its vein carries from three-fourths of a vara to two varas of black gravelly ores which in places are very rich. This *labor* needs a drain to the 11th level, already begun and considerably advanced.

In the 7th, 8th, and 9th levels there are also some workings on this vein, and they can be further opened by driving all the faces further to the west and at the same time pushing the Oscura incline which reaches to the 8th level and has an underground malacate at the 4th level for extracting ore and waste from this working, and also for ventilation.

*The Amarilla Mine,*

which is the one that produces to-day the greatest part of the ore, is entirely dry, as its bottom has yet hardly reached the 5th level, which is  $16\frac{1}{4}$  varas above the water. But ascending to the 4th level, its *labores* are lost and reduced to only the upper ones, which now occupy the greater portion of the miners and which will be extended by continuing the works that are paralyzed.

*The Mine of Los Altos y Colorada.*

Its workings do not extend below the *Santa Yrene* level, which is the third, and therefore the water cannot trouble them. The water will reach the 4th level by November next, and is  $263\frac{3}{4}$  varas deep in the San Francisco shaft.

We agree with the engineer, Don Ricardo Peters, that the water can be extracted in five or six months, at a cost of \$2500 per week, if no serious accidents happen.

[Signed] AGUSTIN PRO.

BELENA, JULY 27TH, 1867.

### GENERAL REPORT

UPON THE BUSINESS OF THE MINES OF FRESNILLO, TRANSMITTED TO THE "JUNTA MENOR PERMANENTE" OF THE ZACATECO-MEXICAN COMPANY, ANSWERING THE VARIOUS QUESTIONS CONTAINED IN THE NOTE OF THE "JUNTA DE FOMENTO Y ADMINISTRATIVA DE MINERIA" FORWARDED TO THIS ADMINISTRATION ON SEPT. 21, 1835, AND IN THE ORDER INDICATED BY THE SAID "JUNTA MENOR" IN ITS COMMUNICATION OF THE SAME DATE.

**1st. The property of the Company consists of the following:**

*Value of the fixed and movable property which the Company received, as per inventory, Sept. 27th, 1835.*

MINES.	\$      rs. gs.
Belén,	37,265. 1. 9.
Barreno,	34,533. 1. 4.
Oscura,	24,088. 3. 0.
Colorada,	56,872. 2. 7. $\frac{1}{2}$
Plateros,	12,408. 5. 3.
San Nicolas,	898. 3. 6.
	<u>165,966. 1. 5. <math>\frac{1}{2}</math></u>
HACIENDAS.	
Guadalupe,	29,694. 3. 3.
Fundición,	4,825. 7. 0.
Rosario,	12,313. 6. 10. $\frac{1}{2}$
	46,834. 1. 6. $\frac{1}{2}$
	212,800. 3. 0.
Property in the house called the "Cuartel de Gendarmes,"	5,423. 0. 0.
Barbechos (Crops) of Alfalfa,	12,759. 7. 9.
Rancho de Valdecañas,	25,652. 2. 6.
	256,635. 5. 3.
Goods in the Hacienda de San José,...	18,542. 2. 1. $\frac{1}{2}$
	275,177. 7. 4. $\frac{1}{2}$
In order to make up the sum of \$285,270. 2. 6. which is the total account for goods, machines, chattels, etc., there yet lacks the sum of \$10,092. 3. 1. $\frac{1}{2}$ , which is not included in this statement because it proceeds from debts inventoried in various departments.	
<i>The Company has invested, from Sept. 27th, 1835, to Aug. 31st, 1844,</i>	
In repairing various structures and building other new ones,	68,628. 3. 8. $\frac{1}{2}$
In building the <i>Hacienda Nueva</i> (New Hacienda),	340,132. 6. 4.
Cost of two steam engines with extra pieces for repairs, in England, transportation, freight, buildings where they are placed, and setting them up,	504,860. 5. 4. $\frac{1}{2}$
	913,621. 7. 11.
For animals, according to statement No. 35, of Aug. 31st ult.:	
654 Horses, @ \$12.	7,848. 0. 0.
1765 Mules,        20.	35,300. 0. 0.
52 Asses,         15.	780. 0. 0.
	43,928. 0. 0.
In materials, such as hammers, steel, quicksilver, etc., etc., was consumed up to Aug. 31st, ult.,	410,552. 4. 0.
Furthermore—2 new steam engines have been purchased, which are now on their way to the mines,	74,525. 5. 9.
Advanced to the Master of Transportation, on account of freights, from May to the said 31st of August,	26,340. 0. 0.
	100,865. 5. 9.
	\$1,744,146. 1. 0. $\frac{1}{2}$

## 2d. Sums expended in the business proper:

	<i>Expenditures and Receipts.</i>
In working and managing the mines, -----	\$17,088,718. 2. 2.
Loan made to the Supreme Government at the time of execution of the contract, -----	1,099,194. 0. 0.
Paid debts contracted by the said Supreme Government, for which the Company was liable, -----	193,518. 0. 0.
Delivered to the Government itself, and on its account and order to the Tobacco Managers, out of what was called the net profits of the Company, -----	<u>499,665. 7. 5.</u>
The Business has paid during the same period, -----	<u>18,881,096. 1. 7.</u> <u>18,641,194. 3. 6.</u>
Deficit, -----	<u>239,901. 6. 1.</u>

3d. Quicksilver, Magistral, Powder, Salt and Fuel consumed in the business of the Company of Proaño in eight years and eleven months, from Sept. 27th, 1835, to Aug. 31st, 1844.

Quicksilver, 16,000 quintals, @ \$133.	\$2,128,000. 0. 0.
Magistral, 65,000 cargas, 4. $\frac{1}{2}$	292,500. 0. 0.
Powder, 19,000 arrobas, 11. $\frac{1}{2}$	218,500. 0. 0.
Salt, { 541,000 fanegas <i>Sal Sierra</i> , 1. $\frac{1}{8}$	608,625. 0. 0.
19,000 " <i>Salgrano</i> , 3.	57,000. 0. 0.
24,000 cargas <i>Sal comun</i> , 7. $\frac{1}{4}$	174,000. 0. 0.
2,000 fanegas <i>Tequesquite</i> , 7. rs.	<u>1,750. 0. 0.</u>
	841,375. 0. 0.
Fuel, { 568,000 fanegas, Charcoal, @ 1. $\frac{3}{4}$ rs.	124,250. 0. 0.
605,000 cargas, Wood, 9.	605,000. 0. 0.
16,000 " <i>Zotol</i> , 2.	<u>4,000. 0. 0.</u>
	<u>733,250. 0. 0.</u>
	<u>\$4,213,625. 0. 0.</u>

4th. In December, 1836, the unwatering was begun with a steam engine. The result was so complete that the 35 *malacates*, which were located at 9 different shafts, were one after another abandoned. The engine has a cylinder 60 English inches in diameter and 10 feet stroke, the pump having a stroke of 9 feet. It was soon found that, the shaft and workings having grown deeper, a single engine was not sufficient to handle the water from all parts of the Cerro, and the Company decided to order another one of equal power from England, which was placed at the *San Francisco* shaft, 80 *varas* west of the *Belen*. With the two engines the desired object was attained up to the year 1842, when it became evident that it was absolutely necessary to order from England two others of greater power with 80 inch cylinders.

The two first cost the Company, -----	\$504,860.
The last two, which will soon commence work in place of the old ones, are estimated at \$190,000, of which there has already been paid about \$125,000.	-----
The difference in the cost of unwatering is as follows:	
That of 43 <i>malacates</i> was \$10,000, though it was afterwards diminished by the stoppage of the 8 <i>malacates</i> at the <i>Plateros</i> shaft, -----	10,000.
The average weekly cost with the two engines amounts to -----	3,250.
Difference, -----	<u>\$6,250.</u>

5th. Average price of Supplies consumed in this Mining Property in the years indicated.

6th. The total number of operatives, artizans and English mechanics em-	
ployed in the interior and exterior work of the mines, including those of the	
reduction <i>Haciendas</i> , amounts to.....	2,800
Employees at fixed salaries .....	150
	2,950

The expenses of the mines since the company began to work them on the 27th of Sept., 1835, up to Aug. 31st, 1844, were \$17,088,718.22, which shows an average weekly expense of \$36,671.

7th. The mines contained in the Cerro de Proaño are eighteen. On the eastern slope: *Beleña*, *Barreno*, *Oscura* and *Hipazote*. On the northern slope: *Salcidos*, *Colorada*, *Santo Domingo*, *Valdenegros*, *Barbosa* and *San Pedro*. On the western slope: *Valenciana*, *Plateritos*, *San Nicolas* and *Espíritu Santo*. On the south: *El Rosario*, *Amarilla*, *Tiro Nuevo* and *Santa Efigenia*.

With the exceptions of *Hipazote*, *Salcidos*, *Rosario* and *Santa Efigenia*, which have long been in ruins, all the rest have been worked by the company, which has spent large sums upon them.

Later, however, the work has been confined to *Beleña*, *Barrenos* and *Oscura*, but leaving in some of the others exploratory works in progress. There is a vast number of prospecting pits and holes of considerable depth, which are not worth reciting in detail.

There are twenty-one shafts in good condition, as follows: *Beleña* and *San Francisco*, general unwatering shafts, 335 varas deep, where the steam engines and pumps are located; *Barrenito*, *Barreno*, *Oscura*, *Buensuceso*, *San Juan*, *Colorada*, *Santo Domingo*, *Saraos*, *Rabago*, *Barbosa*, *Valdenegros*, *Plateros*, *Plateritos*, *San Nicolas*, *Espíritu Santo*, *San Pedro*, *Tiro Nuevo*, *Rosario* and *Amarilla*. Almost all of these have reached the depth of 200 varas except the *Tiro Nuevo*, *Hipazote* and *El Rosario*, which are not so deep. *Oscura* and *Buensuceso* are over 300, and serve for the extraction of ores and waste.

By original documents still existing, it is known that the Cerro de Proaño was working at the beginning of the year 1717. It appears that in 1751 the works were pushed with more regularity, and at that time very rich and abundant ores were obtained for a considerable distance from the *Barreno* as far as the *Oscura* mine and the *San Juan* shaft, which is more than 500 varas. At this time the Administrator General of the mines was a certain Don N. Murgua, who left some considerably detailed accounts of the good condition in which they were when abandoned for want of requisite capital by the party who then controlled them, who was a certain Captain Don M. Muñoz, backed by the old house of Aldaco in that Capital (i. e., in the City of Zacatecas). They were afterwards exploited by various wealthy individuals resident in or near this town (i. e., Fresnillo), but on so small a scale that only the upper portions of the mines were meddled with. It was those notes by Don N. Murgua (which afterwards proved to be extremely

accurate) which led the Government of Zacatecas to undertake the unwatering and working of the mines in 1830, which it continued till Sept., 1835, when the General Government leased the mines to the Zacateco-Mexican Company.

8th. The Company has three *haciendas* for reduction by the *patio* process, that of *Guadalupe*, with 48 *tahonas*; *El Rosario*, with 16; and *La Nueva* or *Grande*, with 250 *tahonas*, which is the number now actually working; but the buildings are arranged for 314.

All the work has been concentrated in the last named *hacienda* with the exception of some smelting ores, very small in quantity, which are worked in the *hacienda* adjoining *Guadalupe*, which contains three furnaces for that purpose.

The system of amalgamation generally employed in the country is the one adapted to the reduction of these ores. With it, the average loss and consumption of quicksilver up to the present time in the current year has not exceeded 10½ oz. per mark of silver produced, with a cost of reduction so moderate that in the last three months it has scarcely reached \$9¾ per *monton* of 20 quintals.

Improved methods of amalgamation have also been tried; but none of them have produced the advantages which their authors promised, and therefore no change has been made in that which is already known and tested.

FRESNILLO, Oct. 10th, 1844.

*DISTRIBUTION MADE IN MEXICO OF THE NET PROFITS OF THIS ENTERPRISE FROM THE 18TH OF DECEMBER, 1841, UP TO DATE.*

		To the Sup. Gov't for the 3d part of the product appli- cable to the re- maininge, its 3d part of the net payment of the advances made as pro- vided.	To the Junta Per- manent, its 3d part of the net profits as pro- vided.	Total.
December, 1841, 18		\$22,460.00	22,450.00	67,360.00
January, 1842, 15		22,460.00	22,450.00	67,360.00
February, " 21		22,460.00	22,450.00	68,360.00
April, " 18		22,460.00	22,450.00	67,360.00
May, " 7		22,460.00	22,450.00	67,360.00
Delivered by the Junta in Mexico to Juan Mejia, Dec. 19, 1835, in part payment of orders issued by the Government in his favor, -----		500.00	500.00	0
Payments made by the Junta for account of the Government,-----		\$113,800.00	-----	-----
Dividend No. 28, made in Mexico on this date,		-----	22,450.00	22,450.00
" " 29, " "		22,450.00	22,450.00	67,350.00
" " 30, " "		22,450.00	22,450.00	67,350.00
" " 31, " "		22,450.00	22,450.00	67,350.00
September, " 24		22,450.00	22,450.00	67,350.00
Reimbursement which the General Treasury arranged to have made for the salary of the Interventor's As- sistant, which was taken from the rents of Sain-Bajo and Laborsita, and which was done by the Junta Menor Permanent in Mexico on the 21st Oct. ult., with the 2 per cent. discount, ----- \$ 519.08		-----	-----	-----
Dividend No. 32, made in Mexico, Nov. 7th, 21,700.00		22,210.08	22,450.00	67,119.08
" " 33, " " Dec. 14th, -----		22,450.00	22,450.00	67,350.00
" " 34, " " Jan. 20th, 1843, -----		22,450.00	22,450.00	67,350.00
" " 35, " " March 7th, -----		15,000.00	15,000.00	45,000.00
" " 36, " " 27th, -----		22,450.00	22,450.00	67,350.00
Salary paid from the Treasury of the Company at Proaño to the Interventor's Assistant, from July 1st, 1842, up to the 3d inst., at \$600.00 per year, -----		194,369.08	-----	-----
Fresnillo, June 3d, 1843.		\$308,725.41	306,850.00	922,425.41

## DIVIDENDS

PAID FROM JANUARY, 20, 1843, TO NOVEMBER, 14, 1849.

NUMBERS.	AMOUNTS.		
34	\$ 67,350 00	January 20, 1843.	
35	45,000 00	March 4, 1843.	
36	67,350 00	March 25, 1843.	
37	168,375 00	July 19, 1843.	
38	101,025 00	September 18, 1843.	
	\$449,100 00		
39	168,375 00	April 1, 1844.	
40	67,350 00	June 7, 1844.	
41	67,350 00	August 18, 1844.	
42	67,350 00	October 10, 1844.	
43	67,350 00	November 11, 1844.	
	437,775 00		
44	67,350 00	January 22, 1845.	
45	67,350 00	March 13, 1845.	
46	67,350 00	May 22, 1845.	
47	67,350 00	June 14, 1845.	
48	67,350 00	October 20, 1845.	
	336,750 00		
49	67,350 00	April 3, 1846.	
50	67,350 00	May 25, 1846.	
51	67,350 00	July 21, 1846.	
52	67,350 00	October 21, 1846.	
	269,400 00		
53 & 54	134,700 00	Last days of Oct. and Jan.	
55	67,350 00	June 16, 1847.	
56	67,350 00		
	269,400 00		
1	201,343 40	Oct. 21, 1847, and Jan. 28 and Mar. 4, 1848.	
2	67,114 40	April 6, 1848.	
3	67,114 40	May 26, 1848.	
4	67,114 40	July 21, 1848.	
	402,687 00		
3	69,313 00	March 24, 1849.	
4	69,940 00	November 14, 1849.	
	139,053 00		
		In 7 years, \$2,304,165 00 which corresponds to \$329,166.35 per year, or, for the whole of the last ten years, a general average of \$230,416.34 per year.	

FRESNILLO, APRIL 4TH, 1853.

*EXTRACTION OF ORE AND COST OF EXPLOITATION OF THE MINES OF PROAÑO FROM 1853 TO 1862.*

YEARS.	Cost of Mining.	Cost of Unwatering.	Total Cost.	Cargas of 300 lbs. each, extracted.	Cost per Carga.
1853	\$289,734.38	\$ 70,186.45	\$359,920.83	190,933.1/2	\$1.889
1854	331,139.56	91,838.39	422,977.95	274,266.	1.710
1855	332,972.00	100,027.48	438,999.48	297,701.1/2	1.474
1856	334,154.45	140,155.31	474,309.76	276,204.1/2	1.717
1857	391,437.36	112,534.98	504,022.34	353,615.2/3	1.425
1858	407,033.71	118,254.03	525,287.74	330,106.2/3	1.590
1859	386,724.81	111,136.94	497,861.75	361,036.2/3	1.379
1860	500,187.92	123,761.32	623,949.24	289,900.1/2	2.152
1861	487,854.43	110,803.98	604,658.41	368,256.2/3	1.642
1862	495,086.02	109,552.97	605,638.99	350,509.2/3	1.727
Totals,	\$3,957,324.64	\$1,100,301.85	\$5,057,626.49	3,092,530.2/3	\$1.632

*RESULTS, MATERIALS CONSUMED, AND COSTS OF BENEFICIATION AT PROAÑO IN TEN YEARS.*

YEARS.	Montones of 300 lbs. each Beneficiated.	Silver Produced. Marks.	Value of the Silver. Dollars.	Salt consumed. Total. Cargas.	Magistral consum'd. Per monton. Cargas.	Quicksilver. Total. Pounds.	Average yield. Marks.	Difference between yield and Assay Value. Per Cent.	Cost of the Beneficiation. Dollars.	Cost per Monton.	
1853	26,640.00	75,217.86	674,704.26	9,660.	4,048	2,936.	1,230	13,522	2,626	21,353	338,625.09
1854	36,847.00	92,595.20	830,578.84	13,973.	4,550	3,388.	1,103	73,386.	12,046	2,512	19,635
1855	44,351.00	98,015.55	879,199.49	18,906.	5,115	4,030.	1,090	76,742.	12,527	2,209	18,920
1856	41,430.65	108,794.40	971,266.24	15,693.	4,545	3,210.	0,929	87,357.	12,893	2,613	22,835
1857	53,042.35	119,727.18	1,073,952.79	20,038.	4,533	5,342.	1,200	108,117.	14,532	2,259	20,683
1858	53,042.35	117,222.38	1,031,484.79	19,866.	4,913	5,330.	1,315	88,532.	12,109	2,411	13,490
1859	47,441.25	116,426.82	1,044,348.58	21,177.	5,336	5,108.	1,294	97,592.	13,412	2,454	10,435
1860	43,485.05	221,561.46	1,090,406.34	20,627.	5,662	7,210.	1,989	103,982.	13,686	2,795	22,000
1861	55,238.50	129,115.17	1,158,163.11	23,123.	5,023	8,555.	1,859	109,983.	13,517	2,337	21,540
1862	52,576.00	118,120.30	1,051,491.24	23,166.	5,287	7,707.	1,758	92,244.	13,036	2,246	24,000
Totals,	452,264.80	1,096,281.32	9,825,595.68	166,229.	4,941	52,816.	1,379	904,306.	13,197	2,424	5,051,766.66
											11.169

The foregoing data [on page 66] are copied from the notes of study of the Practical School of Mines at Fresnillo, extracted from the account books of the Proafio Company with the consent of its Director, Señor Don José Gonzales Echeverria.

[Signed]

MIGUEL VELAZQUEZ DE LEON.

U. S. CONSULATE,  
ZACATECAS, AUGUST 1ST, 1882.

I, the undersigned, Vice Consul of the United States of America for this City and the Dependencies thereof, do hereby certify that the foregoing is the true and genuine signature of Miguel Velazquez de Leon, formerly President of the Mining School at Fresnillo, and as such is entitled to full faith and credit.

Given under my hand and the seal of this consulate the day and year above written.

[Signed]

A. M. KIMBALL.



UNITED STATES CONSULATE GENERAL,  
CITY OF MEXICO, SEPTEMBER 13TH, 1882.

I, David H. Strother, Consul General of the United States of America at Mexico City, hereby certify that the name of A. M. Kimball subscribed to the foregoing certificate is the true and genuine signature of the Vice Consul of the United States at Zacatecas, well known to me, and that the seal thereto affixed is the proper and recognized seal of his office and worthy of full faith and credit.

In testimony whereof I have hereunto set my hand and seal on the day and year next above written.

[Signed]

DAVID H. STROTHER,

*United States Consul General.*



*BURKART GIVES THE FOLLOWING INTERESTING DESCRIPTION  
OF THE CERRO DE PROAÑO (FRESNILLO) MINES IN  
HIS WELL-KNOWN WORK "REISEN IN MEXICO."*

(OF DATE 1832.)

From the summits of the Zacatecas range of mountains, there is plainly visible in the plain towards the north-west, the little peak called "*Cerro de Proaño*," at the foot of which lies the mining town of Fresnillo, 14 leagues from Zacatecas. The city itself cannot be seen from here, because some of the lowest foot hills of the ranges of *Santa Cruz* and *Organos*, running out into the plain hide it from view. The road from Zacatecas to Fresnillo follows the broad valley which separates the ranges of *Santa Cruz* and *Organos* from the range of Zacatecas. After reaching the plain at the foot of the latter range, the road very gently descends towards the north-west as far as the *Rancho de en medio*, which is considerably lower than Zacatecas, being only 6838 Rhenish feet\* above the sea. From here on, the road again gently rises towards Fresnillo, which is 7016 Rhenish feet above the sea.

The working of the mines of Fresnillo had ceased long before the revolution, and as this had previously constituted almost the entire industry of the inhabitants, the city had accordingly grown poor and fallen into decay, and been forsaken by the greater part of its population. But towards the end of the year 1830 the mines of Fresnillo were taken possession of by Governor Don Francisco Garcia in the name and for the account of the State of Zacatecas. About the beginning of 1831, work was resumed upon them. The population of Fresnillo then again increased. The fallen houses were repaired, new ones built, and when I saw the city for the last time in 1834, it was again in the most flourishing condition.

The whole group of the Fresnillo mines are found in the *Cerro de Proaño*, one-fourth of a league south-southeasterly from the city. This hill stands entirely isolated in the plain, above which it rises hardly 330 feet, while its base measures, perhaps, 1500 varas long, by 1200 varas wide. The hill consists of graywacke and clay slate, which underlie a bed about two varas thick of the younger, or recent, whitish-gray limestone. In the limited portion of the "*Cerro*," which I had the opportunity of examining, the graywacke is more common than the clay slate. It is fine grained, often very feldspathic and sometimes approaches compact feldspar.

\* The Rhenish foot equals 1.03 English feet.

Frequently, and especially in the near vicinity of the veins, the graywacke contains large quantities of crystals of iron pyrites scattered through it. The clay slate is generally heavy-bedded, and it is rare that its slaty structure is well defined. In cross fracture it is often fine grained and approaches very closely to schistose graywacke. In the San Francisco shaft, the dark colored clay slate alternates with very thin, fine-grained layers of graywacke, which give the rock a banded appearance. At the same shaft innumerable small stringers of calcite traverse these rocks and cause frequent small faults of the rocky layers, which, owing to the banded structure are very noticeable, and may frequently be observed even in small hand specimens. On the surface of the ground it is almost impossible to find any place where these rocks show any definite law of stratification, and in the mines also this is difficult, as in most of the cross-cuts the beds of graywacke are very heavy. At the shaft in question the stratification is indistinct, and yet the beds seem to strike about N.W., and dip towards the N.E.

In the *Cerro de Proaño*, the veins are very numerous and not very uniform in their strike and dip. It is therefore difficult without accurate detailed maps to obtain a good idea of them. But such are not to be had, and, therefore, though the *Cerro de Proaño* is traversed by veins in all directions, I could only obtain a general idea of the veins which are most worked. The Fresnillo veins traverse both sides of the *Cerro de Proaño* and between the two main shafts of *Beleña* and *Plateros* situated in the plain, one on either side of the *Cerro*, the veins are known for a distance of about 2000 varas, and to a depth of 70 to 80 varas below the mouth of the *Beleña* shaft. Their strike is from N. 60° W. to N. 75° W., and the dip is in the same direction as the slopes of the *Cerro*; those veins in the northeast side of the hill dipping northeast and those in the southwest side dipping southwest. At the outcrop the angle of dip is from 75° to 78°. But deeper down the veins lie flatter, and at the depth of 50 to 70 varas they dip only 50° to 55°. One vein called the *Veta echada de San Pedro* lies much flatter than the rest, dipping only 40° to 45° towards the north, and also differing from the others in its strike.

It appears that the veins are more numerous on the north-eastern than on the south-western slope of the hill.

All over the surface of the *Cerro* from its summit to its foot are broad excavations, which would seem to indicate a great thickness in the veins which have here been worked. But on closer observation we quickly find that the veins themselves were only one to two varas thick, and often less; but in working them considerable quantities of the adjacent country rock have also been excavated. By my later observations in the mines of Fresnillo, I became convinced that the average thickness of the veins probably does not exceed three-fourths of a vara. There are indeed some, like the *Veta Oscura*, &c., which in many places reach a thickness of two and three varas. But there are many others not over one-half a vara thick.

The gangues, the ores, their method of occurrence and distribution in the veins are almost exactly similar at Fresnillo to those in the veins of Zacatecas. But at Fresnillo there are distinguished three classes of ore, viz: "los colorados" "los negros" and "los azulaques," the last of which are not found at Zacatecas. The "colorados" and "negros" are very similar to those of Zacatecas. The "azulaques" appear to me to belong more to the country rock than to the veins; though they are found only in the immediate vicinity of the latter. Here, often for a distance of from one-half a vara to one vara away from the vein, occur iron pyrites, glaserz, horn silver and native silver, scattered in extremely small particles through the mass of the wall rocks. The horn silver and the native silver are found in thin layers on the cleavage surfaces of the rock; the native silver generally as an extremely thin coating with silver-white color and strong metallic lustre. The presence of these ores in greater or less quantity must guide the miner in judging whether it will pay to excavate the rock or not. They often yield a great profit, and it is they which have been the cause of such wide excavations on the narrow veins of Fresnillo. Many years of experience are necessary in order to enable one to judge well the value of the "azulaques" from their appearance. At the first glance one is very often inclined to throw the rock away as worthless, when upon testing with the pan or horn spoon, a large quantity of grains will be found, consisting mostly of horn silver, sometimes mixed with glaserz (argentite, i. e., silver glance), which it pays richly to work.

The average yield of the three classes of ore at Fresnillo in the year 1833 was as follows: the "colorados,"  $3\frac{1}{2}$  ounces per centner; the "negros," 4 ounces per centner, and the "azulaques," 3 ounces per centner. There were, of course, smaller quantities of much richer ores, and considerable ore that yielded as high as from 3 to 4 marks of silver was smelted. But on the other hand, there were large quantities of poorer ores, some of which yielded not over 2 ounces per centner, amalgamated.

The mines of Fresnillo are said to have been worked immediately after the conquest of Mexico, and to have yielded large sums. But the work was early stopped by the influx of water, the quantity of which below the level of the plain seems to have been great. But in the year 1749 several of the mine owners combined to sink four main shafts to facilitate the drainage of the mines. As these were not very deep, the work was soon executed, and a rich production repaid their undertaking. This period of active work lasted till 1757, when it was interrupted by an attachment and seizure of the mines and reduction works, by Don Manuel Aldaca, who had advanced money to work the mines, and then brought his complaint before the Viceroy of Mexico, the *Marques de las Amarillas*. The mines and reduction works were awarded to Manuel Aldaca, only four "pertenencias"\*\* remaining to the former owners. The drainage of the mines, and all works of exploration and development were then stopped, so that the

\* A "pertenencia" is 200 varas square.

lowest levels soon became inaccessible, while the upper portions of the mines were everywhere robbed as fast as possible of all that seemed to promise any immediate profit. After that time the mines were not worked, and it seems that even the documents proving their former richness remained hidden away in the archives at Mexico; for a company of English capitalists, under the name of "The Mexican Mining Company" possessed the mines for a number of years without even instituting a search to satisfy themselves whether the richness of the mines would justify any undertaking to work them.

It was reserved for the activity and zeal of Governor Don Francisco Garcia to again open up the richness of these mines. Those old documents fell into his hands and he soon convinced himself that it was of the greatest importance to the State of Zacatecas that the mines of Fresnillo should be reopened.

From the end of Nov. 1832 to the same day of 1833, the yield of Fresnillo was over 332,000 centners of ore, and is said to have considerably increased since then. In consequence of the excessive cost of hoisting the water, which is still done by horse whims, and also of the round-about, tedious and costly management, as well as of some other matters connected with their working, the mines of Fresnillo do not yet, indeed, yield any very large profit, but are nevertheless said to have already paid back a part of the money expended in reopening them.

*TREATMENT OF THE SILVER ORES OF MEXICO BY THE SO  
CALLED BENEFICIO DE PATIO. TRANSLATED  
FROM DUPORT'S WORK,—*

*"DE LA PRODUCTION DES MÉTAUX PRÉCIEUX AU MEXIQUE," CONSIDÉRÉE DANS SES  
RAPPORTS AVEC LA GÉOLOGIE, LA MÉTALLURGIE ET L'ÉCONOMIE POLITIQUE,  
PAR ST. CLAIR DUPORT. PARIS: FIRMIN DIDOT FRÈRES, 1843.*

The ore to be amalgamated is always, in works of any considerable importance, subjected to the action of stamp mills, called *molinos*. These machines, composed of eight wooden stems, furnished at their lower end with cubes of wrought iron (*almadanetas* = stamp heads), are set in motion by a cam shaft which is sometimes driven by a water wheel, but oftener by a horse or mule whim. Where there is water power the pulverization by stamps is continued until the ore is fine enough to amalgamate, and with the proper amount of power one *molino* prepares 8,000 lbs. (3,680<sup>k</sup>) in twenty-four hours.

In most haciendas, however, the only motor being a whim, the operation is not pushed so far and the ore is only reduced to coarse sand. The mules hitched to these "*molinos*" travel very fast, and the service of each "*molino*" requires eighteen mules, which work successively, three at a time. About 11,000 lbs. (5060<sup>k</sup>) are stamped in twenty-four hours, and the *almadanetas* are worn out in six months.

The *porphyrisation* (pulverization) of the ore already reduced to coarse sand by the stamps, is effected by machines called *arrastras*, or *tahonas*. In different localities one *arrastra* grinds from 600 lbs. (276<sup>k</sup>) to 1500 lbs. (690<sup>k</sup>) in twenty-four hours, according to the character of the ore and the fineness of the grinding. Water is used in the *arrastras* in the proportion of about 1½ of water to 1. of ore by weight.

The archives of the little town of Pachuca having been twice pillaged, no details can be found as to the patio amalgamation at the very place where it was discovered. The most ancient documents which mention it are a report addressed to the Viceroy of Mexico by Barrio de Montalvo, printed in Mexico in 1643, and a memoir from Dias de la Calle to Philip IV, printed in Madrid in 1646.

The discovery of this process is there attributed to Bartolomé Medina, a miner of Pachuca, in the year 1557, without giving any indications of the way in which he arrived at this result.

But, although there are no documents in existence to show by what methods Bartolomé Medina arrived at the discovery of the *beneficio de patio*, there are several which prove that, with the exceptions of a more rare use of lime, and the

substitution of horses or mules for the feet of men in treading the ore, very little change has been made in this method since its discovery. On issuing from the *arrastras* or *tahonas*, the ore is deposited in almost a liquid condition in basins of masonry called *cajetes* or *lameros*—*lama* (i. e. mud or pulp) being the technical term employed to designate the pulverized ore as it comes from the arrastras, while the word *granza* is applied only to the coarse sandy product of the stamps.

The quantities of the pulverized ore are designated by the number of *montones*. The *monton* varies at different localities:

At Guanajuato	it is	3,200	Spanish pounds	=	1,472 <sup>k</sup> .
At Zacatecas	"	2,000	"	=	920 <sup>k</sup> .
In other districts	"	1,800	"	=	828 <sup>k</sup> .

A certain number of *montones* form the *torta*, which at Guanajuato often contains 1,500 to 1600 quintals (69,000 @ 73,600 kil.) of ore; while at Fresnillo it is composed of sixty *montones* of twenty quintals each, or 120,000 lbs. (55,200 kil.)

As soon as a sufficient quantity of ore is collected to form a *torta*, it is carried to the *patio*, which is simply a vast court whose floor, being paved with tiles, is but slightly pervious to water and not much more so to mercury. The semi-liquid ore is poured into provisional basins, the sides of which are merely loose timbers, covered with horse manure, which serve to retain the ore within the proper limits. The evaporation, under a generally clear sky and the low barometric pressure on the table land of Mexico, is sufficiently rapid so that in from four to eight days, according to the season, the excess of water has disappeared and only enough remains so that the feet of the animals treading the pulp can without too much effort reach the floor of the *patio*. The quantity of water left in the pulp, however, varies considerably. It is worked much drier at Guanajuato than anywhere else. A *torta* of 150,000 lbs. (69,000 kil.) there occupies a circle 15 metres in diameter, with a depth of 0.25 metre.

The first proceeding now is to *ensalmorar*, i. e. to mix the ore with salt. The quantity of salt used varies but little and corresponds to 75 lbs. (34.50 kil.) per *monton* of 3,200 lbs. (1,472 kil.), or a little over 2½ per cent. Next, the *torta* is given what is called a *repaso*, by turning over the whole mass of ore with wooden shovels and afterwards treading it for several hours with from eight to fifteen horses or mules, according to the dimensions of the *torta*.

The word *azogue*, which is the one generally preferred for *quicksilver* in Mexico, has given the name of *azogueros* to the directors of amalgamation. Some of these add the *magistral* with the salt, while others only add it twenty-four hours later.

As, owing to various causes, the quality and degree of active energy of the *magistral* vary greatly, the quantities employed cannot be definitely fixed, and must also vary with the nature of the ore. At Guanajuato from 30 to 60 lbs. (13.80 to 27.60 kil.) are employed per *monton* of 3,200 lbs. (1472. kil.)

The mixture of salt and *magistral* being well incorporated, the addition of mercury begins. The first dose is called *el incorpo*, and consists of two-thirds of

the whole quantity of mercury destined for the operation, the quantity of which is approximately estimated at six times the weight of the silver which the ore is expected to yield. Immediately after *el incorporo* a new *repaso* is given.

It is by inspection of the mercury and the amalgam that the *azogueros* follow all the phases of the operation. This is done by means of very frequent tests called *tentaduras*. A test is made by washing about eight ounces (230 grms) of ore, collected from twenty or thirty different points in the *torta*, in a sheet iron pan, or a horn spoon, or in a sort of calabash, the fruit of a tree of the hot region, called by the Indians *xicalcuahuitl*. By first stirring the paste with the fingers and then giving it an oscillatory motion at the surface of a basin full of water, the latter carries off all the lighter parts of the ore and there remain at the bottom of the spoon only the metallic portions and the mercury. By then retaining a little clean water in the spoon, holding it somewhat inclined, and giving it a very gentle motion, the various substances arrange themselves in the following manner: At the upper edge are found particles of mercury slightly altered (*desechos*) and very finely subdivided (i. e. "floured quicksilver"), with a little silver amalgam in very fine grains, which have given it the name of *limadura* (filings). The metallic *schlich* (*asiento*) comes next, and lower still is found the liquid mercury or the already solidified amalgam. After having separated the *limadura* from the *asiento*, the *azoguero* rubs the former against the sides of the spoon with his thumb, and according to its color and the greater or less difficulty which he experiences in making it pass into the condition of a drier amalgam in irregular shapes called *pasillas*, he judges of the commencement of the work.

The *tentadura* taken immediately after the *repaso* which follows *el incorporo*—except when the ore is very rich in native silver—gives at the bottom only liquid mercury, and at the top a little floured mercury and a beginning of *limadura*. In this first *tentadura* the color of the mercury should be observed with special care. When it preserves its natural color or has only a bronzy shade upon its surface, it is a sign that the reaction is going on slowly, and the *torta* is said to be "cold." If the surface of the mercury is moderately gray, the operation is going well. But if it is a dark gray, and the upper part of the *tentadura* shows an ashy gray powder which refuses to unite into globules by friction, the reaction is too rapid; the mercury is attacked and the *torta* is said to be "hot."

If the proportion of *magistral* has been such that the reactions advance properly, at the end of twenty-four hours after the *incorporo*, amalgam is found in the liquid mercury, and on pressing it out but little *desecho* is seen at the other extremity, where it has been replaced by a coarser and more consistent *limadura*, which passes into *pasillas* by friction.

The *repasos* are one of the means of increasing the activity of action of the *magistral*. They are not resorted to except when the daily inspection of the *limadura* and the mercury indicates the need of them.

After fifteen, twenty or thirty days, according to the season and the nature of the ore, the mercury is no longer liquid, but has been transformed into dry

amalgam, which at last will not yield the smallest drop on being pressed between the thumb and forefinger. More mercury is then added. This is called *cebar* (to feed). Generally  $\frac{1}{12}$  of the total amount of mercury is now added, which takes about ten days to pass into the state of dry amalgam. The last twelfth is then added, and as a general rule it does not become completely dry. If that should happen, however, the quantity of mercury would be increased until the certainty was reached that no more could solidify, the *torta* being in a suitable condition to facilitate amalgamation. Then the *azoguero* says that the *torta* has yielded (*rendido*); i. e. that it has already given up all the silver which mercury can extract from it.

If in the course of the operation it is perceived in repeating the *repasos* that the *limadura* and the amalgam, already united in one mass, do not increase in quantity, the *torta* is "cold;" *magistral* is added and the amalgamation recommences. If, on the contrary, the mercury is covered with a dark gray pellicle, and the *limadura* is replaced by *desecho*, lime or ashes are added in order to "cool" the *torta*, which is too "hot;" the *repasos* are suspended and not resumed until the disappearance of the alarming symptoms has been effected by the palliatives, which the *azogueros* always dread to employ, because they retard the operation and diminish the yield of silver, without revivifying the portion of mercury already uselessly attacked.

One thus sees that it is not without reason that Barba compares the testing spoon to a mirror in which the *azogueros* can see all the features of the ore under treatment. Without pretending to isolate the examinations of the different parts of the *tentadura*, one may say that the color of the mercury is the guide for the proportion of *magistral*, that the condition of the *limadura* indicates the daily progress, and that the greater or less degree of solidity in the amalgam determines the addition of more mercury, and the end of the operation.

At Guanajuato, the most skillful *azogueros*, when thoroughly familiar with a given mixture of ore, do not fear to keep their *tortas* a little "hot," and claim that in so doing there is a gain both in the time required and in the yield of silver, without greater loss of mercury. At Zacatecas and Fresnillo, where the ore abounds in metallic sulphurets, more *magistral* is employed, especially in the presence of galena; the color of the mercury is habitually such that a Guanajuato *azoguero* would be very uneasy about it. But with these ores it suffices when these symptoms are too strongly developed, to leave the *torta* for a few days without *repasos*, when, without the addition of lime, the operation resumes its regular march. Nevertheless, in winter the conduct of the amalgamation demands at Zacatecas, and especially at Fresnillo, special precautions on account of the tendency which the *tortas* have to become "hot" in cold weather, though the amalgamation may be greatly retarded. I will indicate hereafter the probable cause of this singular effect of a lowering of the temperature.

The characteristics of the *tentaduras* are not very clear except for those who have studied them with patience for a long time. But for such they are definite

enough so that, except in case of rare anomalies, two *azogueros* will always render the same judgment as to the condition of a *torta* in process of working; but they are not so sure as to the point at which it is proper to consider the operation ended, and from this fact considerable differences of yield result. In a sort of competitive trial between different *azogueros*, with the same character of ore mixed and weighed with the greatest exactness, the results showed a difference between the most and least skillful ones of seven per cent. in the amount of silver obtained, though all the competitors were skillful workmen, and the annual product in silver of the ore treated by each one of them represented a value of several hundred thousand dollars.

As soon as the *torta* seems to be *rendido*, preparations are made to wash it. At Guanajuato the ore is carried immediately from the *patio* to the washer, in the bottom of which the amalgam accumulates, mixed with about one-eighth of its weight of ore.

At Zacatecas and Fresnillo, before carrying the ore to the washer, there is added to the *torta* a quantity of mercury amounting to seventy-five or eighty per cent. of that previously employed. This addition is called the bath (*el baño*), and the washing is continued until the liquid amalgam remains almost absolutely pure in the bottom of the washer (*lavadero*).

At Guanajuato the *lavaderos* are vats of wood or masonry which in the principal haciendas have the following dimensions: Diameter = 3 m.; depth = 1.70 m. The wooden stirrers = 0.55 m. Three of these vats are connected with each other by openings 0.20 m. high and 0.30 m. long, which are placed, one of them, 0.20 m. and the other 0.90 m. above the bottom of the *lavadero*. There are, besides, in the last vat two discharge openings; the highest one is 0.18 m. above the bottom and is 0.12 m. in diameter. It serves to discharge the waters. The lowest one, which is only opened in order to clean out the bottom, is 0.06 m. in diameter, and touches the bottom of the vat. Each operation involves three *montones* of 30 quintals (4,140<sup>k</sup>) of ore which is poured in little by little without ever permitting any stoppage of the four mules which move the stirrers in the three vats by means of gearing. For three-quarters of an hour the stirrer makes six revolutions per minute; afterwards for two hours and three-quarters it makes only three. The weight of the deposit which remains in the bottoms of the vats after having drawn off the water through the holes situated 0.18 m. above the bottom, is estimated at about one eighth of that of the *torta*. This deposit, mixed with dry amalgam, is carried away in large wooden bowls (*bateas*) which serve to separate the amalgam by hand washing in large basins filled with water. This last residue, called *relaves*, is subjected to a new treatment, which I will describe later.

At Fresnillo the washing is executed in a single vat of masonry 2.75 m. diameter and 2.33 m. deep. To avoid the filtration of mercury into the ground the bottoms of these vats at Fresnillo and in the principal haciendas of Zacatecas are discs of porphyry 3.40 m. diameter and 0.60 m. deep.

Two of these vats, without any intercommunication, however, are placed side

by side, in such a way that a single whim worked by four mules drives the stirrers of both vats. The movement is more rapid than at Guanajuato, and each vat washes  $2\frac{1}{2}$  *montones* of 20 quintals (2,300 kil.) per hour, and the amalgam almost entirely freed of ore is taken from the bottom of the *lavadero* without requiring to be washed by hand.

This more expeditious method is also much less perfect than that of Guanajuato, and accordingly the washing of the residues on "Planillas," which is superfluous at Guanajuato, is indispensable and produces much amalgam at Zacatecas and Fresnillo. In place of vats with stirrers, at Real del Monte, Tasco and the mining districts near the City of Mexico, a wooden box is used, into which runs a current of water which afterwards escapes through discharge holes at different levels. This box being nearly full of water, the ore is poured into it, while men stir it with shovels and open the discharge holes one after another, till at first the lighter particles, and afterwards the heavier ones, being carried off by the water, leave the amalgam almost pure in the bottom of the box. The water charged with ore, on issuing from the box, runs through sluices with riffles for a distance of 30 to 40 metres, by which means a part of the amalgam carried out of the box is caught in the riffles, which are cleaned up at each operation. This method is undeniably the most costly in labor, and especially the most ruinous on account of the losses of mercury and silver which it involves.

When the mercury has been well cleaned of the last particles of ore by wiping it with flannel, it is filtered through bags of which the upper part is leather and the lower part closely woven canvas. The weight of the amalgam is sufficient so that a considerable part of the mercury filters through in a liquid state and drops into a vat lined with leather placed beneath. In the amalgam which remains on the filter it may be generally estimated that the weight of the mercury is four or five times that of the silver. This proportion varies according to the quantity operated on, the silver being more abundant when the weight filtered at once is greater. The amalgam in the upper part of the filter is much richer than that in the middle and yet more so than that in the bottom, which often does not contain more than one-seventh of its weight of silver.

When taken out of the filter, the amalgam is placed on leather-covered tables, and moulded and pressed into little triangular wooden moulds forming fractions of a disc, and called "*marquetas*." This is necessary in order to form with the pieces a column, destined to be covered with a bronze bell in order to separate the mercury from the silver by heat.

This operation, called "*refogar*," is executed by placing the column of amalgam on an iron support, which, without entirely closing the opening beneath, rests over a reservoir of masonry containing a quantity of water constantly renewed by a stream flowing through it. By means of a pulley, the bronze bell is let down over the column, till its lower edge rests in a groove, which is sometimes filled with water, and sometimes sufficiently luted with clay to prevent all escape of mercury. A wall of circular bricks is built around the bell at a little distance

from it, and the space between the two is filled with charcoal, which produces a temperature high enough to volatilize the mercury, which re-condenses in the cold water in the reservoir beneath. After eight or ten hours of firing the operation is ended. When it is conducted with care, the loss of mercury is insignificant, not exceeding one ounce (28.76 grs.) per 100 lbs. (46 kil.) of mercury obtained.

The silver obtained from well washed *tortas* is very fine, and is generally received as pure at the mints.

After the distillation of the mercury, the silver is melted into ingots, which according to the Spanish *Ordenanzas*, could not exceed 136 marks (31.28 kil.) in weight. A few great mining organizations have the privilege of converting their own silver into ingots. But as a general rule the law requires that this melting shall be done in the laboratories (*oficinas*) of assayers appointed by the Government and established in the principal mining districts.

Thus it appears that when the ore is once pulverized, the silver is extracted from it by the *benificio de patio*, with no other apparatus than a washer and a bronze bell, with no labor beyond the treading of the pulp by the feet of men or animals, with no fuel except that required for the roasting of the *magistral* and the retorting of the amalgam, and finally without any other ingredients than two to three per cent. of salt and one to three per cent. of *magistral*, and with a loss of mercury concerning which it will be necessary to enter into some details.

*The following Explanation is given by Duport (p. 74) of some of the Terms used in Smelting.*

*Greta* is the litharge, often very impure, which comes from the treatment of the lead ores of Mazapil and Mapimi for the northern districts, and those of Zimapán for the southern one. Its price varies from \$2.50 to \$4.00 per quintal (46 kil.), according to the distance it is transported. The litharge obtained in the treatment of silver ores contains but little silver. A *greta* from Sombrerete gave me only 0.00005 in silver. That of Mazapil contained a little more. The color of these litharges, greenish yellow, is undoubtedly due to the presence of copper, which they contain in notable quantity.

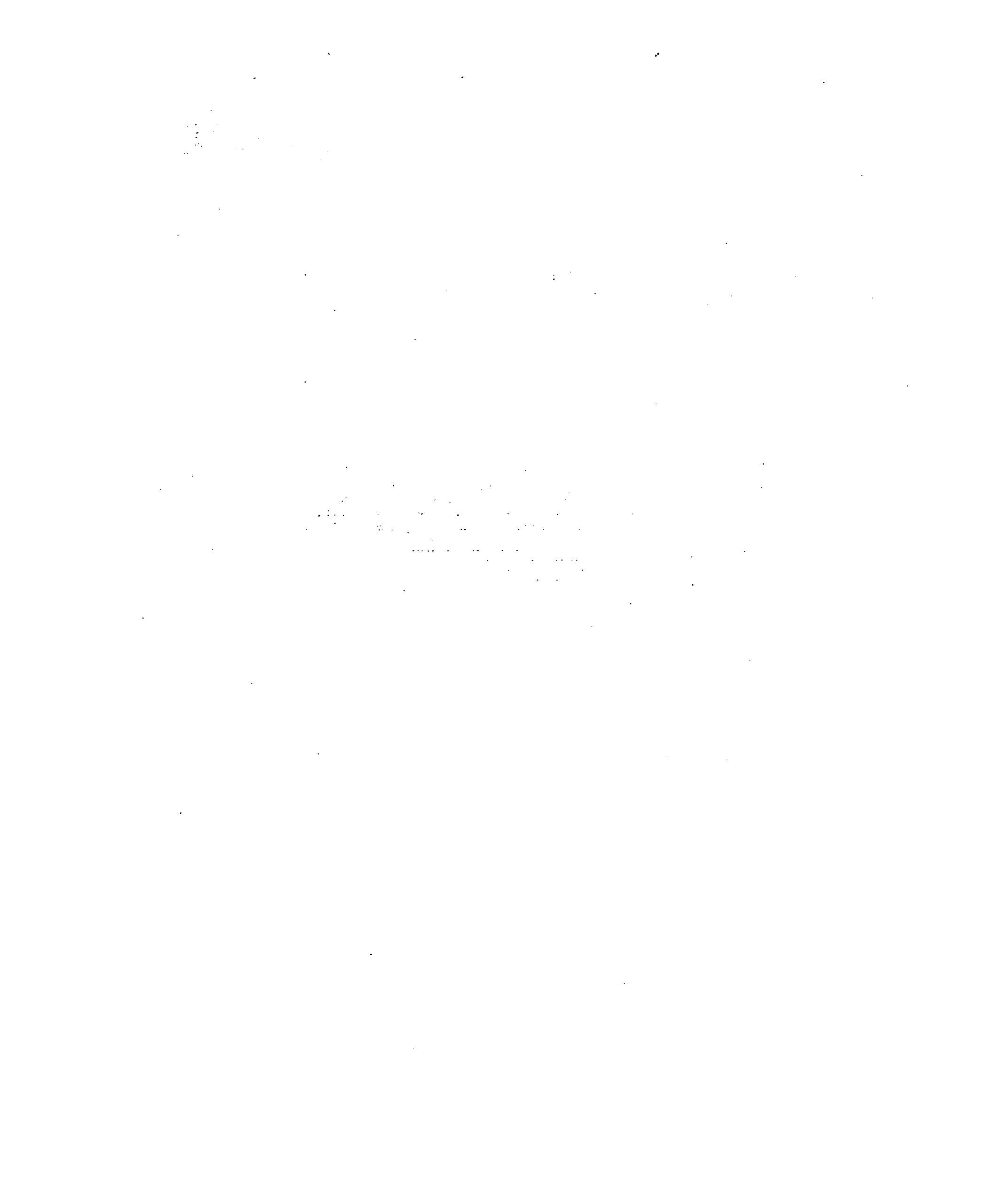
*Temesquitate* is the scoria which swims on the surface of the bath of lead in which rich ores in powder are directly treated. That of Sombrerete yielded me by assay 0.0004 of silver.

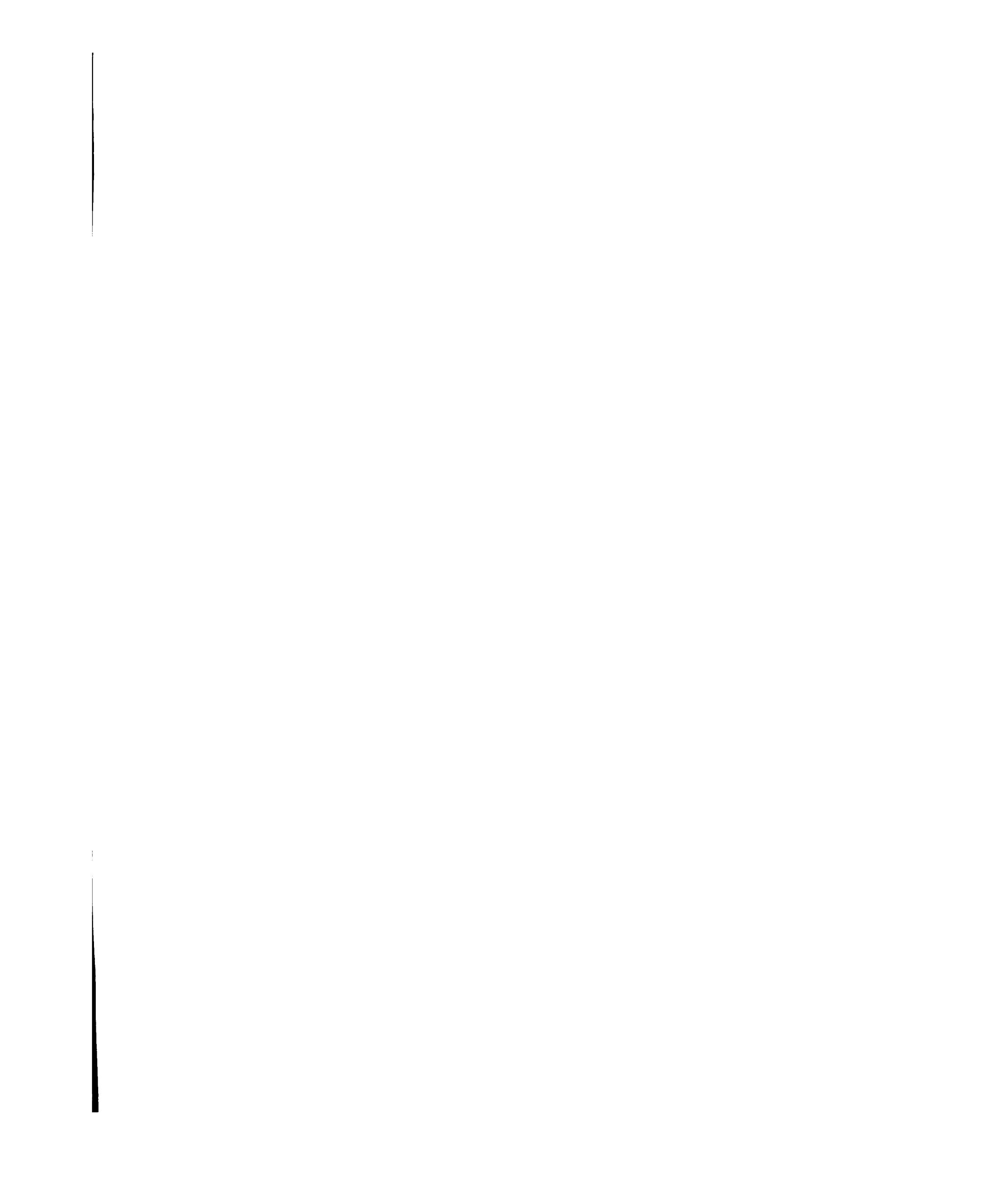
*Crasas*, or scoriæ from smelting, vary much in richness according to the character of the ore and the skill of the smelter. An assay of *crasas* from Sombrerete, from the treatment of rich ore, gave 0.0003 of silver, while that from *Nieves*, from ore containing 0.0025 contained 0.0005 of silver.

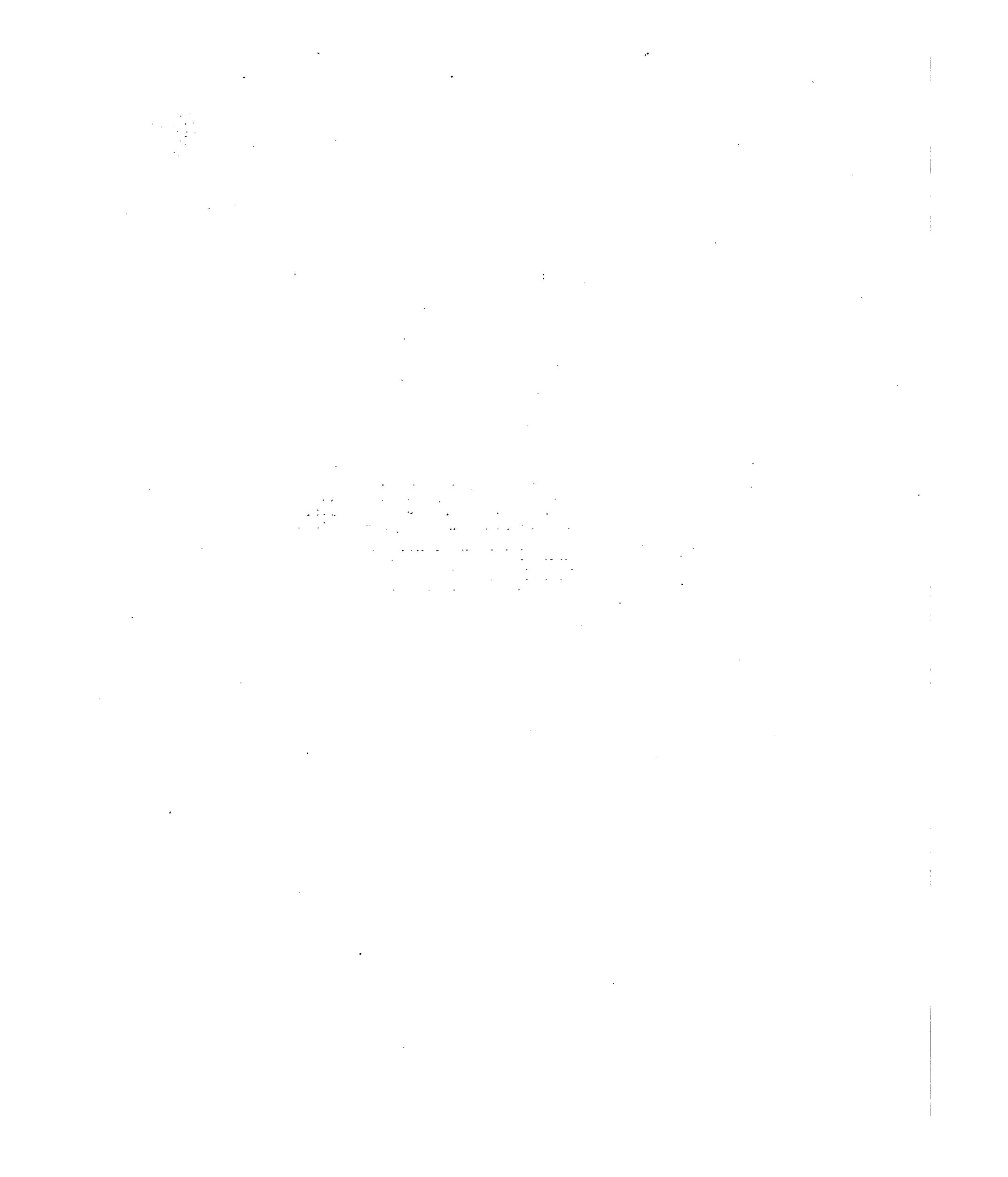
*Fierros* are the abzugs and abstrichs which swim on the surface of the lead bath at the commencement of cupellation. Under this same name of *fierros* are also designated the mattes which cover the lead in the receiving basin, and which are removed and returned to the same furnace whence they came.

*Tequesquite* is a natural carbonate of soda which is found in considerable abundance on all the plains of the Mexican plateau, where after the rainy season it appears on the surface of the ground as a floury efflorescence, which the winter frosts change into a crust. The chief source of this material for the Zacatecas region is the alkaline lake of Peñon Blanco, a natural reservoir about half a league long and a little less than half as wide. In the absence of rains in March, which are very rare, it is in April that the harvest is made of a very dry and whitish crust which covers the whole dry bed of the lake. After gathering it together in heaps on ground high enough to be above the highest stages of water, it is covered over with earth to protect it from the rains, and thus the *tequesquite* is preserved for years, to be disposed of according to the requirements for consumption. The price of this flux on the ground is only 56½ cents per fanega, which amounts to about 5 francs per 100 kil. According to an analysis made at the Paris School of Mines under the direction of M. Berthier, the *tequesquite* consists of

Anhydrous carbonate of soda,.....	0.516
" sulphate " .....	0.153
Common salt,.....	0.045
Water,.....	0.246
Earthy matters,.....	0.030
	0.990

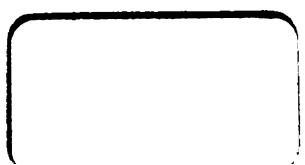






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Sketch of the great historic mines  
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